Department for Transport

TRANSPORT ANALYSIS GUIDANCE

Guidance for the Senior Responsible Officer

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Department for Transport

Transport Analysis Guidance (TAG)

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Technical queries and comments on this guidance should be referred to:

Transport Appraisal and Strategic Modelling (TASM) Division
Department for Transport
Zone 2/25 Great Minster House
33 Horseferry Road
London
SW1P 4DR
tasm@dft.gov.uk

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1 The Transport Appraisal Process

This Section has been prepared for the Senior Responsible Officer (SRO), and aims to provide knowledge on how appraisal broadly works and how the evidence derived from the transport appraisal process can be used to support the **Transport Business Case** [DfT, 2011].

The relationship between the transport appraisal process and the decision-making process is summarised in Figure 1.1 below. This Unit will expand on the broad activities within the transport appraisal process (indicated by the un-shaded activities in Figure 1.1), and provide explanations on the key links to the development of evidence for the business case.

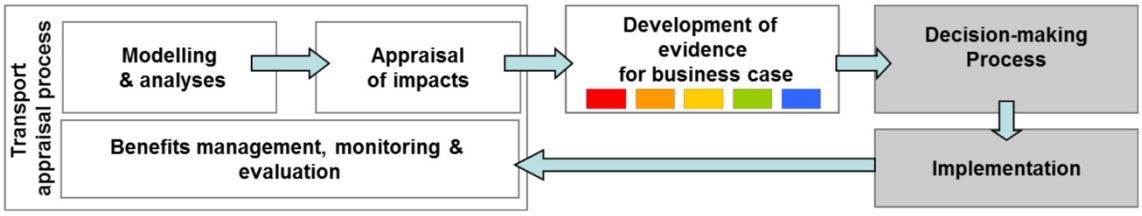

Figure 1.1 Relationship between the transport appraisal process and the decision-making process

1.1 Relationship between appraisal and decision-making

1.1.1 The summary relationship in Figure 1.1 can be expanded in the form presented in Figure 1.2.

1.1.2 A typical transport study is initiated when a mandate (see box in top right corner of Figure 1.2) is established by the sponsoring organisation. This usually arises from a need by sponsoring organisations to fulfil a set of wider policy objectives. The transport appraisal process (see column on left) commences, and involves undertaking a broad range of analyses generating the evidence required to identify and support the business case development process.

1.1.3 The transport appraisal process encompasses option development and analyses and the appraisal of impacts generated by each option. These activities are represented by rectangular boxes, and enable the production of appraisal outputs. The appraisal outputs are then used in developing the evidence base (see middle column of Figure 1.2 with coloured bars) to support the business case. Note that the business case needs to be considered from five perspectives – strategic, economic, financial, delivery and commercial – and these elements are represented by the set of coloured bars. The extents to which the bars are filled indicate the level of completeness of each case as the study progresses.

1.1.4 The business cases are presented to the relevant decision-makers(represented in the right-hand box). The decision-points in this process are represented by the diamond-shaped boxes.

1.1.5 Overall, the relationships expressed in Figure 1.2 highlight that the transport appraisal and decision-making processes are separate but related. Whilst TAG provides good practice guidance on appraisal, the guidance on decision-making describes a separate process with specific investment criteria governed by the respective investment boards (e.g. DfT, Network Rail, Highways England, Local Authorities etc.). The decision-making process for investment decisions in the Department for Transport is described in The **Transport Business Case**.

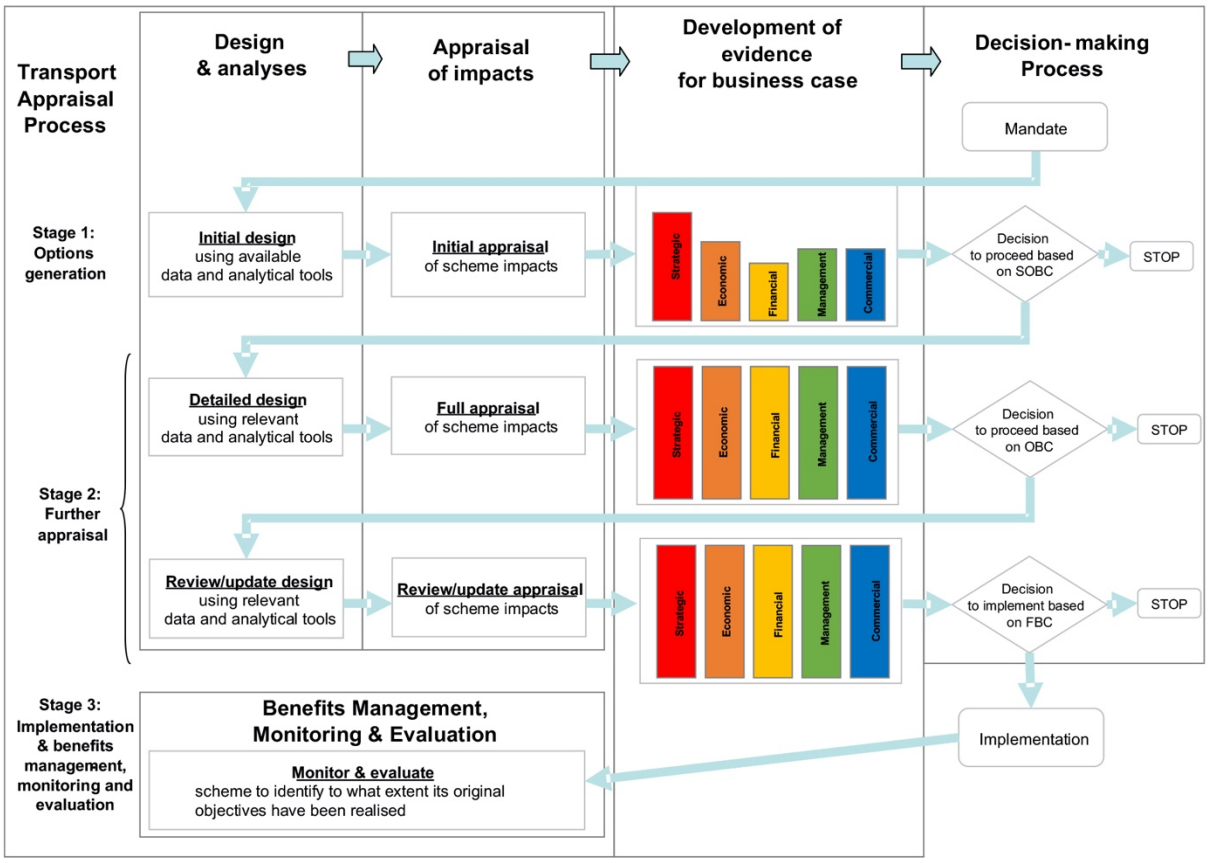

Figure 1.2 Detailed relationship between the appraisal and decision-making process[1]

Note that the level of completion of the five cases, as shown by the vertical bars, is indicative of broad trends only; this will vary on a case-by-case basis across schemes.

1.2 The Appraisal Process

1.2.1 The transport appraisal process has been designed based on HMT's Green Book principles on transparency and proportionality. To ensure transparency in the development of options, scheme promoters should involve key stakeholders from the early stages of the study process. On proportionality, the Green Book states that all new proposals should be subject to comprehensive but proportionate assessment, wherever practicable, so as best to promote public interest. This has been applied in the transport appraisal process at two levels. Firstly, the guidance recommends that a lighter-touch appraisal is applied in the early appraisal stage of options development. Secondly, a lighter-touch appraisal can be applied for smaller interventions than for larger interventions. These concepts are further elaborated in the following sections. The transport appraisal process consists of three broad stages:

Stage 1 – Option development

1.2.2 Stage 1 follows after the mandate for the transport study has been established. The key focus here is to identify the problems and case for change to be addressed by the transport study. There is more detailed guidance on this in **Transport Business Case**. Following this, the next steps are then to develop a broad range of options to address the study objectives, and short-listing options based on assessment against the criteria set out in the 5 case model. Whilst this 5 case model approach is discussed in greater detail in the later part of this unit, it is worth mentioning at this point, that analysts need to consider the Strategic, Economic, Financial, Management and Commercial case even from early stages of the transport study.

[1] SOBC = Strategic Outline Business Case; OBC = Outline Business Case; FBC = Full Business Case.

1.2.3 It is also important to initiate stakeholder engagement at this stage, involving stakeholders early in options generation/development and sifting to ensure that the proposed options are fit-for-purpose, and to gather public support and acceptability for the proposed options. Hence, a stakeholder strategy will need to be established early in the study process, and should address who to involve and when.

1.2.4 The cost benefit analysis approach requires a wide range of impacts to be analysed for each option being considered. However, in this early stage, it would be disproportionately burdensome to conduct full analyses of impacts of each option when only a few options will be select for further appraisal (stage 2). Instead, it is recommended that proportionate efforts are applied using 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 transport model at this stage. Intervention promoters should discuss this aspect with intervention sponsors if in doubt.

1.2.5 At the end of this stage, the project should achieve the following outcomes:

a) **Identification of preferred options for further appraisal in Stage 2**. The process of identifying the need for the intervention, the assessment of each option against the criteria set out in the 5 case model, and recommendations on the short-list of preferred options need to be documented. Guidance for the Technical Project Manager (TPM) provides more details on the suggested scope of such a report – this is referred to as Options Assessment Report (OAR) in TAG; and

b) **Define the scope and methodology for further appraisal of the preferred options**. Before embarking on detailed analyses, it is good practice for analysts to define and seek agreement with the assessors on the scope and methodology for undertaking further appraisal of the preferred options in Stage 2. Guidance for the Technical Project Manager provides more details and suggestions on what to consider in such a scoping report – this is referred to as the Appraisal Specification Report (ASR) in TAG.

1.2.6 Completion of an ASR provides the opportunity to bring together all the key parties (promoter, designer, technical analysts, etc.) at an early stage to ensure a proper design process is undertaken for the appraisal activity and that this is understood by all parties. A well produced ASR to which all parties have contributed is a key tool for planning appraisal work and for risk mitigation in the appraisal process.

1.2.7 Generally, the three areas that demand a significant proportion of resources are Modelling, Environmental Impact Assessment (EIA) and Distributional analyses. Figure 1.3 below describes the relationship between these three components. The ASR should set out how these components will be considered early to ensure smooth flow of information from one component to another. For example, modelling and Environmental Impact Assessment are both resource-intensive tasks; it would be prudent for analysts in both teams to agree on input/output data early so as to prevent abortive work later on in the appraisal process.

1.2.8 On modelling, it is emphasized that although detailed transport modelling is usually required for major transport interventions, the full extent of such analyses and detail may not be necessary for some smaller interventions. In this way, the methods and analyses recommended in the next stage should be proportionate to the scale of the intervention. Section 3 provides further guidance on modelling for transport interventions.

1.2.9 It should also be highlighted that although Environmental Impact Assessment is a statutory requirement, and separate from appraisal, the outputs from the Environmental Impact Assessment can be used to support the assessment of environmental impacts in the Appraisal Summary Table (AST – see section 2.3). Guidance for the Technical Project Manager provides further information on dependency of appraisal on the Environmental Impact Assessment. Detailed guidance on conducting the Environmental impact Assessment for highway interventions is provided in **Volume**

11 of the Design Manual for Roads and Bridges (DMRB 11). For other modes, the guidance in DMRB may provide a useful starting point.

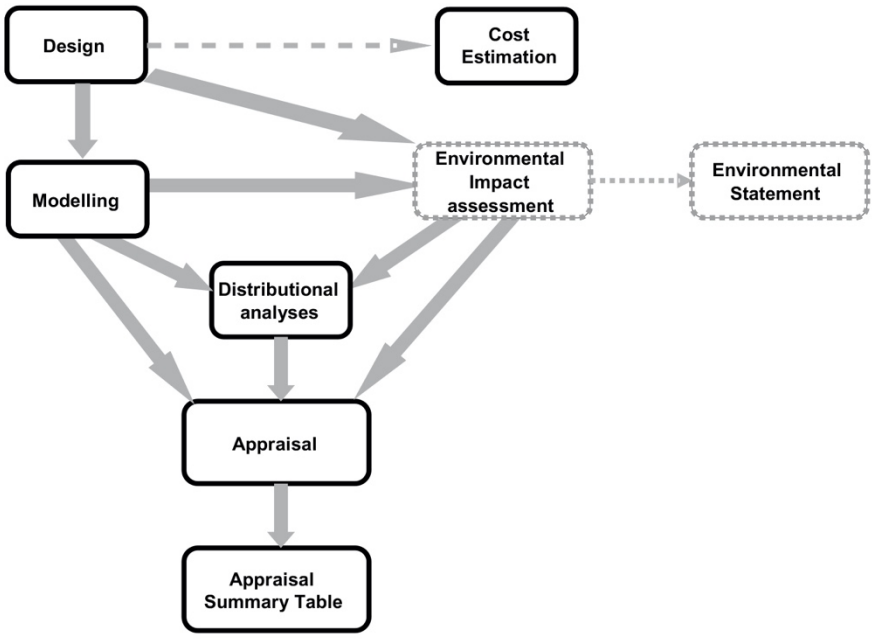

Figure 1.3 Relationship between the key components of appraisal work

Stage 2 – Further appraisal

1.2.10 Based on the ASR produced in Stage 1, promoters would either adapt or create new tools to conduct detailed analyses to derive the evidence that is used to develop the business case. At the end of this stage, analysts need to produce:

a) detailed analyses of intervention against a wide range of impacts including economy, environment, society, distributional, and government (public accounts). Section 2 describes the nature of these impacts. Guidance for the Technical Project Manager contains further information on the practical considerations of analysing these impacts. There is detailed TAG guidance for the Technical Practitioner on how the model and other tools can be used to produce these analyses; and

b) the performance of each option against the sub-impacts are distilled and presented in the form of an **Appraisal Summary Table (AST)**. One AST needs to be completed for each option being considered.

Stage 3 – Implementation and Benefits Management, Monitoring and Evaluation

1.2.11 By this stage, the decisions on the preferred option would have been made. The key considerations here include implementation and benefits management, monitoring and evaluation.

1.2.12 At the implementation stage, analysts should consider the phasing of the delivery programme, clearly establishing when each component is required, by when, the problems that are likely to emerge if not done; interdependencies and critical paths; accounting for capabilities of transport providers; reconcile phasing with funding arrangements.

1.2.13 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. This work should proceed during the implementation stage.

1.2.14 To ensure that benefits management, monitoring and evaluation work can proceed successfully, analysts should take steps to document and store outputs from appraisal and modelling, through an appraisal handover pack. This ensures that outturn benefits can be compared with forecasts so that any divergences can be learned from (for further details, see guidance for the Technical Project Manager).

1.2.15 Finally, it should be emphasised that although Stages 1 through to 3 have been treated in a simplified linear process in this guidance, iterations occur in practice – especially between Stages 1 and 2.

1.3 How The Transport Appraisal Process Aligns With The Decision-Making Process

1.3.1 The previous section sets out the broad principles and considerations of the transport appraisal process. The purpose of this section is to elaborate how the transport appraisal process fits with the decision-making process.

1.3.2 The decision-making process applied in the Department for Transport has been developed based on HMT's best-practice '5 Case Model' [HMT]. The relevant guidance for the transport context is set out in the **Transport Business Case.** It sets out how investment decisions are made, and highlights what information is required at the different stages to inform decision-making for investment funding.

1.3.3 Essentially, analysts are required to develop a business case giving due consideration, and providing evidence on:

- the Strategic case: demonstrating the case for change and strategic fit delivered by the proposal, providing a clear rationale for the proposed investment;
- the Economic case: assessing the Value for Money [DfT, 2017] of the proposal. This considers all impacts delivered, and analyses whether the proposal presents good value for tax payers' money;
- the Financial case: analysing the financial profile of the investment, and identify funding and accounting issues;
- the Management case: demonstrating that project planning (phasing and delivery of implementation), risk management and stakeholder engagement has been addressed; and
- the Commercial case: demonstrating that financial implications, risks of proposed commercial deal, risk allocation and transfer have been addressed in the proposed procurement strategy.

1.3.4 Figure 1.2 illustrates that there are three key decision-points in the decision-making process. These are indicated by the diamond shapes in the flow diagram.

Decision to proceed based on the SOBC (Strategic Outline Business Case)

1.3.5 The information presented to the decision-maker at this stage should enable recommendations to be made on provision of the initial agreement to proceed with the intervention. As indicated by the coloured bars in Figure 1.2, the strategic case would typically be more advanced than the other four cases at this early stage. This is expected, because there needs to be strong justifications on "the case for change" and "strategic fit" before further analytical effort is invested in appraisal.

1.3.6 The Options Assessment Report (OAR) – produced at the end of the first stage of the transport appraisal process, contains analyses on the 5 cases that can be used to support the production of the business case at this point.

Decision to proceed based on the OBC (Outline Business Case)

1.3.7 Whilst the first decision point had a stronger emphasis on the strategic case and secures initial approval to proceed, the second decision-point focuses on detailed assessment of the options to find the best solution. At this point, the business case would require fully detailed analyses for the 5 cases; this is indicated by the fully coloured bars in Figure 1.2. Based on this evidence, the decision makers decide whether or not the intervention should move into the final phase of study.

1.3.8 The Appraisal Summary Table (AST) that is produced at the end of stage 2 of the transport appraisal process can be used directly to inform the Value for Money assessment for the Economic Case.

1.3.9 The supporting analyses that are produced as part of the transport appraisal process may also be used to support the other four cases. For example, the Greenhouse Gases analysis produces a monetary impact, which can be used as part of comparing the overall costs and benefits in the Economic case; it also produces the total carbon emissions within specific time bands This can be used to address how well the scheme performs in delivering the sponsoring organisation's carbon reduction targets in a Strategic Case. A full listing of these analyses and how they can potentially be used to support the other cases are listed in Figure 1.4 below.

Decision to proceed based on the FBC (Full Business Case)

1.3.10 This is the final decision-point where the Full Business Case is presented to decision-makers. The final decision is then made on whether or not to implement the intervention.

1.3.11 The outputs from the transport appraisal process – the AST and supporting analyses – can be used to support the Full Business Case in the same way as in the preceding decision-point. The fully coloured bars in Figure 1.2 suggest that, in the same way as for the OBC, all five cases are fully developed in the FBC. This is possible given that the time elapsed between the decision-points could be a few years, requiring the business case – and hence the AST and supporting analyses – to be reviewed/updated again with more up-to-date information/assumptions.

1.3.12 Analysts should also be aware that, in addition to the transport appraisal process, there are also other mode and/or investment-specific guidance that need to be adhered to. The outputs produced from these would also be fed into the business case. A list of these other requirements is presented in the bottom half of Figure 1.4.

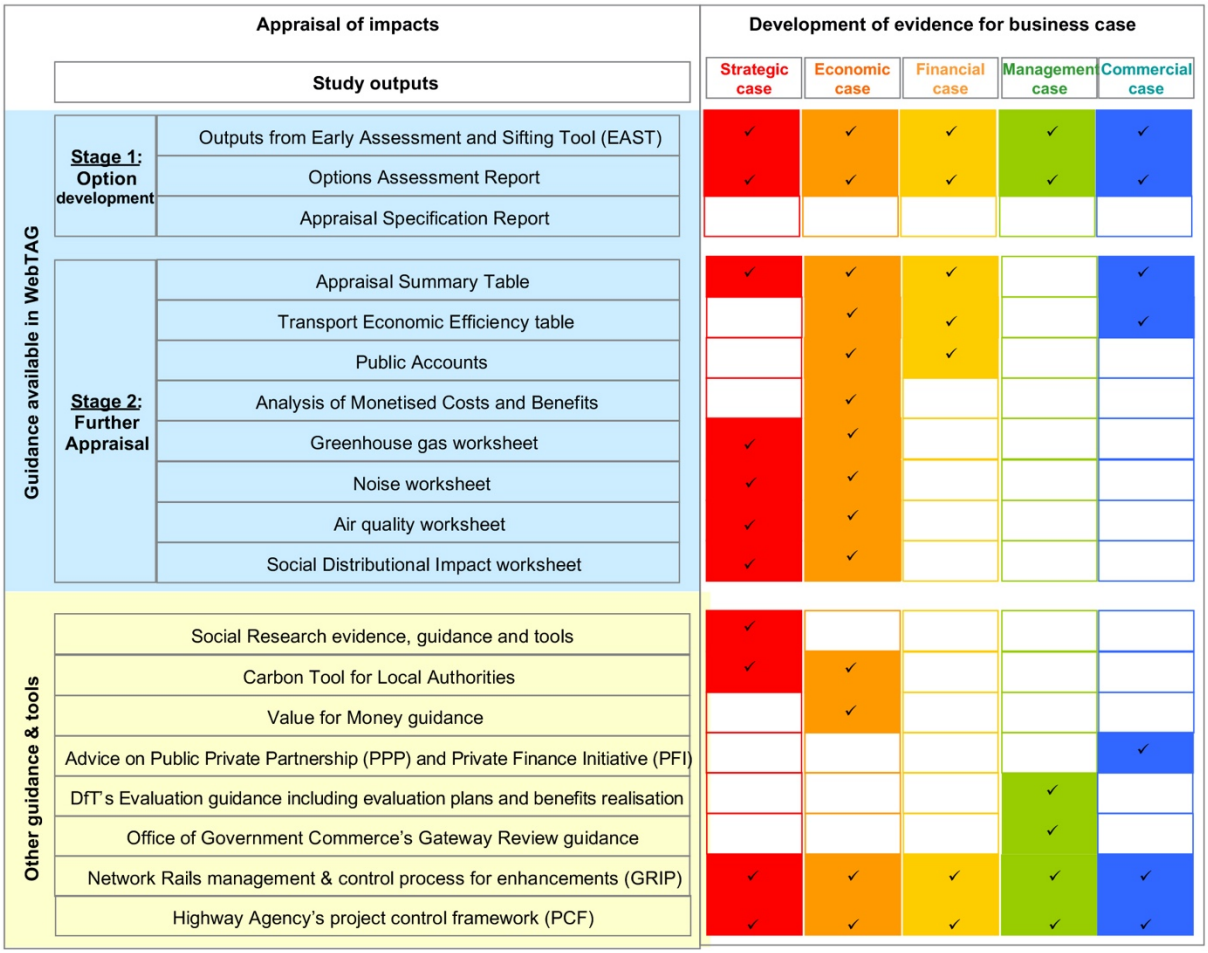

Figure 1.4 Tools and guidance produce evidence that can be used to answer questions posed by each case within the 'Five Case Model'

1.4 Conclusion

1.4.1 To conclude, the transport appraisal process and the outputs that are generated from it form the evidence framework that supports the development of the business case.

1.4.2 It is also worth highlighting that appraisals are often iterated a number of times – to fine-tune the detailed design of the intervention, or to incorporate concerns from stakeholders – before the intervention is implemented in full. Hence, in practice, the stages may be repeated and not always be followed sequentially.

1.4.3 In practice, the requirement for evidence at the different stages (timing) might vary across different investment appraisal frameworks and modes. For practical purposes, the guidance provided here is described in more general terms, and it is for the Project Executive and Project Manager to apply these frameworks and methods to their specific needs.

2 Summary Advice on Appraisal

This Section aims to provide the SRO with knowledge about how the key principles of appraisal set out in the Green Book [HMT, 2007] have been applied in the transport appraisal framework. The discussions will also highlight the impacts assessed in cost-benefit analysis, illustrating how these outputs can be used as part of developing the evidence base for the **Transport Business Case**.

The relationship between the transport appraisal process and the decision-making process is summarised in Figure 2.1 below. This unit elaborates on "Appraisal of impacts"; this is indicated by the un-shaded activities in Figure 2.1.

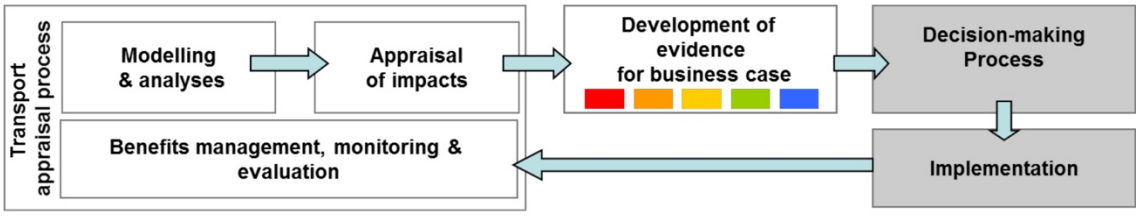

Figure 2.1 Reproduced with focus on appraisal of impacts.

2.1 Principles Underlying the Appraisal Framework

2.1.1 The Green Book (GB) [HMT, 2007] sets out best practice guide to appraising and evaluating policies and capital projects. It constitutes binding guidance for all central governments and executive agencies, and aims to make the appraisal process throughout government more consistent and transparent. The key principles that have been applied in the transport context are set out below.

2.1.2 The GB recommends that options should be appraised using **cost-benefit analysis**. This requires analysts to assess and report on a wide range of impacts at the national level.

2.1.3 The analyses for scheme impacts should **quantify in monetary terms** as many of the costs and benefits of an intervention as feasible, including items for which the market does not provide a satisfactory measure of economic value. It also recognises that there may be impacts that cannot be quantified or monetised. Where this is the case, weighting, scoring, or a multi-criteria approach can be used.

2.1.4 The GB also highlights the need to consider **distributional effects**, and recommends that these should be explicitly stated and quantified as far as possible. At a minimum, this requires appraisers to identify how the costs and benefits accrue to different groups in society. If, for example, the costs of a government action fall largely upon one ethnic group this impact should be detailed in the appraisal. It follows from this that a rigorous analysis of how the costs and benefits of a proposal are spread across different socio-economic groups is recommended. Where it is considered necessary and practical, this might involve explicitly recognising distributional effects within a project's NPV.

2.1.5 In addition, there are also a number of legal obligations related to social and distributional impacts. In particular, the Equality Act (2010) introduces a new public sector Equality Duty to advance equality and tackle discrimination; this enshrines in law the role of public bodies in narrowing gaps in outcomes resulting from social disadvantage.

2.1.6 As most decisions to implement a proposal or particular option will have far reaching consequences, the GB also states that the presentation of the conclusions and recommendations to decision-makers and key stakeholders can be as important as the analysis itself. In all cases, **transparency** is vital.

2.1.7 Finally, recognising that there can be a wide range of analyses that can be undertaken in scheme appraisal, the GB recommends proportionate assessment, wherever it is practicable. The effort

applied at each step should be proportionate to the funds involved, outcomes at stake, and the time available.

2.2 The Appraisal Framework

2.2.1 The transport appraisal framework has been developed and designed based on these key principles laid out in HMT's GB. The four broad areas that are considered are impacts on the economy, environment and society, as well as impacts on the government (public accounts).

2.2.2 The appraisal of "**Economic**" impacts describes how the scheme impacts directly on the economy, mainly in terms of time, monetary value, and employment. The following economic sub-impacts are appraised:

- "Business users & transport providers" analyses the impact on business users' journey times and vehicle operating costs and costs to business users during construction and maintenance The investment and operating costs incurred by the private sector transport operator should also be included here;
- "Reliability impacts on Business users" analyses the impact on business users' journey time reliability. Note the distinction between journey time reliability and average journey times. The latter is reported under the previous impact on "Business users & transport providers";
- 'Wider Economic Impacts' analyses – the impact on the wider economy including induced investment, productivity and employment impacts.

2.2.3 The appraisal of "**Environmental**" impacts describes how the scheme impacts on the wider environment. The sub-impacts identified are:

- "Noise" analyses the impact on sensitive receptors (e.g. residential properties) of changes in noise levels as a result of the intervention;
- "Air quality" analyses the impact of changes in exposure to NO_2 and PM10 as a result of the intervention;
- "Greenhouse gases" analyses the overall change in greenhouse gases (including carbon dioxide) emitted as a result of the intervention. The impact on traded and non-traded carbon should also be presented separately;
- "Landscape" analyses qualitatively the landscape impact of the intervention;
- "Townscape" analyses qualitatively the townscape impact of the intervention;
- "Historic environment" analyses qualitatively the impact of the intervention on the historic environment;
- "Biodiversity" analyses qualitatively the biodiversity impact of the intervention; and
- "Water environment" analyses qualitatively the impact of the intervention on the water environment.

2.2.4 The appraisal of "**Social**" impacts describes how the scheme impacts the society. The sub-impacts identified are:

- "Commuting and Other users" analyses the impact on non-business users' journey times and vehicle operating costs and costs to users during construction and maintenance;
- "Reliability impacts on Commuting and Other users" analyses the impact on non-business users' journey time reliability. Note the distinction between journey time reliability and average journey times. The latter is reported under the previous impact on "Commuting and Other users";

- "Physical activity" analyses impacts on cycling and walking that affect users' physical fitness. It is especially important for the appraisal of cycling and walking schemes, but may also be relevant where other projects affect levels of cycling and/or walking;
- "Journey quality" analyses the impacts of the intervention on journey ambience, crowding, transport interchange quality and other quality impacts;
- "Accidents" analyses the change in number and monetary value of fatal, serious and slight accidents and casualties;
- "Security" analyses impacts on crime or the fear of crime within the transport context;
- "Accessibility" analyses how the intervention affects the range of opportunities and choices people have in connecting with jobs, services and friends and families;
- "Affordability" involves analyses on how the intervention affects people as a result of changes in the transport costs. This is chiefly a distributional impact that focuses on the impact on vulnerable groups such as households with low incomes;
- "Severance "involves analysis of the separation of residents from facilities and services they use within their community caused by substantial changes in transport infrastructure or by changes in traffic flows; and
- "Option and non-use values" analyses the value of preserving transport options for their potential use or the value of the existence of services to individuals when they are not used. This is particularly relevant to service closures, i.e. the closure of rail stations.

2.2.5 The appraisal of "**Public Accounts**" describes how the intervention impacts financially on government. This includes all costs incurred by central or local government bodies (including public sector agencies). The sub-impacts identified are:

- "Cost to Broad Transport Budget" analyses the total costs –project construction costs, including the cost of land, property, preparation and supervision and changes in maintenance cost – and the breakdown of these cost implications for local/central government. It also recognises that some interventions have impacts on local or central government revenues that affect the funding that is available for transport; and
- "Indirect Tax Revenues" analyses the impacts on tax receipts from fuel taxes and VAT. These impacts are not included in "cost to the broad transport budget" because they do not affect the amount of money available for transport purposes.

2.2.6 These results are pulled together and analysed using cost-benefit analysis. To facilitate comparison, the assessment of impacts are quantified and monetised wherever possible. However, for impacts that cannot yet be quantified robustly, then a qualitative analysis is required to ensure that all key impacts are taken into consideration in the design of new interventions.

2.2.7 Schemes could also have distributional effects across different socio-economic groups, especially the vulnerable groups e.g. lower income, disabled, children. Where this is the case, distributional effects need to be considered as part of the design process, ensuring that distributional impacts are mitigated wherever practicable.

2.2.8 For the purpose of this guidance, the SRO should be aware of the range of appraisal outputs/analyses that can be can be produced from the available guidance. In particular, analysts should note that appraisal outputs are sufficient to build the evidence for the Economic case. For the other cases, however, analysts should also be aware of, and apply separate mode-specific and/or investment-board specific guidance. Figure 1.4 provides a list of these tools and guidance.

2.3 The Appraisal Summary Table (AST)

2.3.1 As mentioned earlier, transparency in the presentation of conclusions and recommendations to decision-makers and key stakeholders is as important as the analysis itself.

2.3.2 To facilitate, the Appraisal Summary Table has been designed to enable intervention promoters to summarise the results of their analyses and communicate to decision-makers/assessors the key economic, environmental, social and distributional consequences of the proposed intervention. Hence, the AST is a key output of the transport appraisal process.

2.3.3 The AST contains information on:

- Name of the intervention: Include the option reference;
- Description of intervention: Includes a few key words of text which summarise the main thrust of the option;
- Date produced; and
- Contact information: Includes information on the name and organisation of the person who is responsible for the information contained in the AST in case further information is required. Also states whether the person is a scheme promoter or an assessor.

2.3.4 The key points in relation to each of the sub-impacts are briefly summarised in the "**Summary of key impacts**" column.

2.3.5 The "**Quantitative**" column should be used to report impacts in "real world units". For example, the greenhouse gas impact should be measured in tonnes of carbon dioxide equivalent emitted, and user benefits should be measured in minutes saved. Where monetary values can be derived, as in the case of accidents or transport economic efficiency, these monetary values should be reported under the "**Monetary**" column. Impacts that cannot be quantified should be assessed on a (usually) seven point scale (note that these scales are not necessarily cardinal in nature) and reported under the "**Qualitative**" column. However, because each seven point scale measures a very different objective, they cannot be compared with each other.

2.3.6 Where relevant, distributional analyses are also required to understand how the impacts are distributed across the vulnerable social groups. At the moment, methods have been established to assess the distributional impacts within the sub-impacts on Noise, Air quality, Commuting and other users, Accidents, Security, Access to services, Affordability and Severance. Where these distributional impacts are relevant to the scheme, a qualitative assessment of the extent and the vulnerable groups affected should be reported under the "**Distributional**" column.

2.3.7 Overall, the layout 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. The standard template ensures that all impacts are presented. For comparison, the impacts are monetised wherever feasible, based on available monetary valuations. If monetary valuations are not available, it is still important to present the impacts in qualitative and quantitative terms. No further weightings are applied.

2.3.8 It should be emphasised that the efforts employed in applying the appraisal framework should be proportionate. For example, the first stage of the transport appraisal process requires analysts to generate a wide range of options before short-listing preferred options – against a set of criteria -- to proceed into stage 2. To undertake full analyses for all the initial options, where the majority would be discarded would be resource-intensive and inefficient. It is recommended that stage 1 (option development) of the appraisal process is conducted as a desk-based exercise using readily available data and tools. Although the use of the AST may not be appropriate in Stage 1, the same principles of considering a wide range of impacts and analyses of qualitative, quantitative, monetary and distributional impacts still apply. The analyses and evidence of these impacts would be used to

support the "Economic Case", presented in the Options Assessment Report produced at the end of Stage 1.

2.3.9 In stage 2 (further appraisal), however, intervention promoters will be required to undertake more robust analyses, and present the evidence gathered within an AST for each option that is being considered.

2.3.10 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. **Transport Business Case** sets this out in further detail.

2.4 Appraisal Methods

2.4.1 To conduct cost benefit analysis of all impacts, appraisal techniques that are consistent with the Green Book [HMT, 2007] are applied to enable consistent comparison of impacts.

2.4.2 The appraisal period for each intervention needs to be defined. This is the period of useful lifetime of the assets encompassed by the options. Analysts are required to quantify, wherever possible, the impacts (benefits and costs) for the individual years within this appraisal period. Some projects – new roads or railway lines, for example – have indeterminate lives. In these cases, a standard appraisal period should be used.

2.4.3 To bring these impacts to the same units for comparison, monetary valuations are applied wherever possible to convert the respective quantities into monetary values. For example, values of time are applied to convert the time savings (in minutes) calculated by transport models into a monetary value for time-savings. Some of the valuations that are applied in transport appraisal can be taken directly from prices paid in markets, or predictions of prices in future markets e.g. fuel prices. Other valuations have been derived from research using techniques such as hedonic pricing and stated preference e.g. the valuation of some noise impacts, and the value of travel time savings. Where valuations rely on research or experimental methods they are reviewed by experts to ensure that they are robust enough to be used in cost-benefit analysis.

2.4.4 It is worth including a caveat at this point, that there are some other impacts where it is currently infeasible to derive a reliable monetary value for. However the fact that these impacts are not expressible as monetary values should not lead to the conclusion that they are neglected by the decision-maker. Instead there is guidance on how to present these in a consistent form that gives a clear sense of the severity of the impact, even if the impact cannot be simply added or subtracted from the other impacts that have been expressed in units of money.

2.4.5 The Green Book also requires that the valuation of costs and benefits to be expressed in "real terms", i.e. to remove the effects of future inflation in the analysis of impacts. For this reason, valuations and monetary impacts should be expressed to a consistent price base. All valuations and monetary impacts should be reported in the Department's standard base year.

2.4.6 Having established the monetary impacts occurring in the individual years within the appraisal period, discounting is then applied to convert the costs and benefits that occur in the different time periods, to a "present value" so that they can be compared. This is a separate concept from inflation, and is based on the principle that, generally, people prefer to receive goods and services now rather than later – this is known as "social time preference". As a result of this, the present value of £1 will diminish the further away into the future it occurs. The discount rates used in transport appraisal are consistent with Green Book recommendations. Calculating the present value of the differences between the streams of costs and benefits yields the net present value of the option (NPV).

2.4.7 Finally, the GB also emphasises that risk management strategies need to be adopted in appraisal. In transport appraisal, the concepts of optimism bias and uncertainty are applied.

2.4.8 Generally, appraisers tend to overstate benefits and understate project durations and costs. In applying optimism bias, these estimated costs should be factored according to the stage of the appraisal, and the extent of confidence in the cost estimates.

2.4.9 The concept of uncertainty is applied in the production of future forecasts of travel patterns using a transport model.

2.5 Conclusion

2.5.1 To conclude, the transport appraisal framework has been built on a cost-benefit analysis approach. This requires analysts to assess how the intervention affects a wide range of impacts including the economy, environment, society and government. These are summarised in the form of an Appraisal Summary Table, which is used directly in the Value for Money assessment (the Economic case). In some cases, the supporting analyses for the impacts can also be used to support the other cases. However, analysts should also be aware of, and apply, separate mode-specific and investment-board specific guidance in the production of the business case.

3 Summary Advice on Modelling

This Section gives an introduction to modelling that is of use to the Senior Responsible Officer (SRO) and should act as a general introduction, outlining the high-level considerations for model development to support the development of evidence in transport appraisal.

3.1 Introduction

3.1.1 Modelling is a tool used in the transport appraisal process in order to produce input for the various analyses required in the appraisal process. These analyses are ultimately brought into the decision-making process and are aimed at providing the decision-maker with the best evidence in order to draw the right conclusions. These analyses are often composed of costs and benefits of a potential transport intervention and also quantities, such as future traffic flows, for analyses of impacts on the economy, environment and social landscape. Figure 3.1 below shows where modelling fits in to the appraisal process.

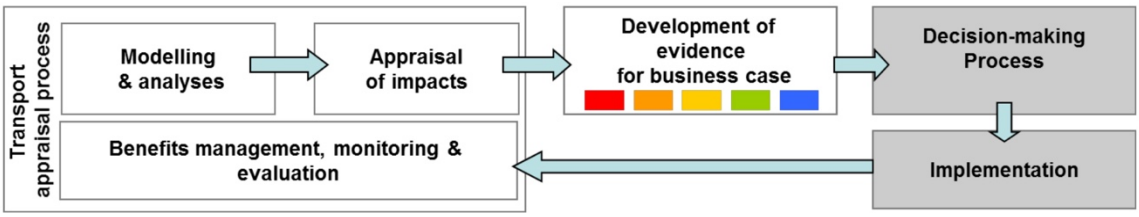

Figure 3.1 Modelling in the transport appraisal and decision making processes

3.1.2 The consequences of transport interventions providing solutions to more severe transport problems will often be particularly widespread and complex. Changing transport conditions will affect the decisions of individuals both directly and indirectly. The extent to which different modes of transport are used is liable to change over time and changes to transport provision also may affect the distribution of land use in some cases. Models are the tools that attempt to simulate these complex interactions, to an extent that they have the appropriate level of sophistication compared to the scope of the intervention and its impacts (are **proportionate**) and that they provide robust and evidence-based foundations for decision-makers (are **fit-for-purpose**).

3.1.3 It is important that an appropriate level of effort is provided to assess these consequences, to ascertain the extent to which objectives are met and problems solved, and to estimate the value for money of the project. The creation of a transport model, along with the collection of the necessary data, is potentially costly and time consuming. Thus, it is sensible to consider the role and requirements of modelling at the outset of the appraisal work.

3.1.4 All stages of the decision-making process are informed by analysis, at a level of sophistication that is required for each stage. For instance, in “Stage 1” of the decision-making process, the requirement of which is to select the best transport options to solve the identified problems, more light-touch methods and hence modelling tools may be appropriate. It is of course important that the results of more simplified models or analyses do not mislead and cause less well conceived projects to come forward into the later decision-making stages.

3.1.5 At “Stage 2” (Full Appraisal), more robust analyses are expected in order to present the best evidence to the decision-maker. At the full appraisal stage, given the complexities of the transport system and the scope of most schemes that apply for central funding, it is expected that a computer model of some or all of the transport system will be required. In a 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.

3.1.6 Before committing resources to data collection and model building, it is vital that:

- the nature of the options that need to be tested are specified;

- a modelling approach is chosen that is adequate to test the options and support the associated appraisal processes;
- the scope for using existing models and data carefully considered, providing they are fit for purpose to test the options; and
- any new models and data must be carefully specified to ensure that they are fit for purpose to test the options.

3.1.7 The approach to modelling must be guided by the intervention to which the model is being applied. In principle, other issues such as programme budget and time scale should not be the primary considerations in model development. Where they exist, previously developed models should only be used if they can be modified to be fit for the purpose of assessment of the intervention.

3.1.8 As already mentioned, model development can be complex and costly. Consequently, where parts of model development need to be repeated either as a result of errors, rectifying an inappropriate choice of method, or improving its accuracy to meet required standards, can take considerable time and resource. Altered model outputs may require rework of downstream analyses leading to delay and additional cost. The SRO should be aware that these are material risks for the project and that an open dialogue should flow between the SRO, technical project manager on the modelling side and the project sponsor (e.g. the Department).

3.1.9 The appropriateness of the modelling approach and the model data to be used should be discussed with the project sponsor before getting too far down the development path, which risks an inappropriate approach being developed at potentially substantial cost. The ASR plays an important role in establishing clarity for the modelling approach to be adopted and ensuring agreement more formally. The ASR should be revisited when planning model development where a model is to be changed or updated for use in a subsequent decision-point. Separate Guidance for the Technical Project Manager (TPM) clearly lays out the expectations of a model's fitness-for-purpose and associated reporting requirements in more technical detail.

3.2 General Principles

3.2.1 Two broad mechanisms are used in traditional transport modelling. These are the modelling of supply and demand.

3.2.2 Supply conditions are modelled using network models of the transport system in order to calculate the costs of travelling in terms of monetary cost and time (referred to as 'generalised cost'). It effectively calculates the choices of route that people take to get from their origin to destination. Supply models can exist for different modes, usually in the form of a model of the road network and a model of the public transport network (the network used by buses, trams or trains). The scope of the intervention(s) being assessed will determine the requirements of each.

3.2.3 Demand models are required to ascertain the change in travel behaviour of individuals in reaction to the changes in cost from the changed supply conditions. For example, where car congestion on the roads increases over time, people may decide to shift to public transport modes, travel to alternative locations or even travel less. The demand model takes these responses into consideration and simulates the choices that people make given the options that are available to them.

3.2.4 Figure 3.2 shows the mechanisms of a traditional supply and demand model for a given forecast year.

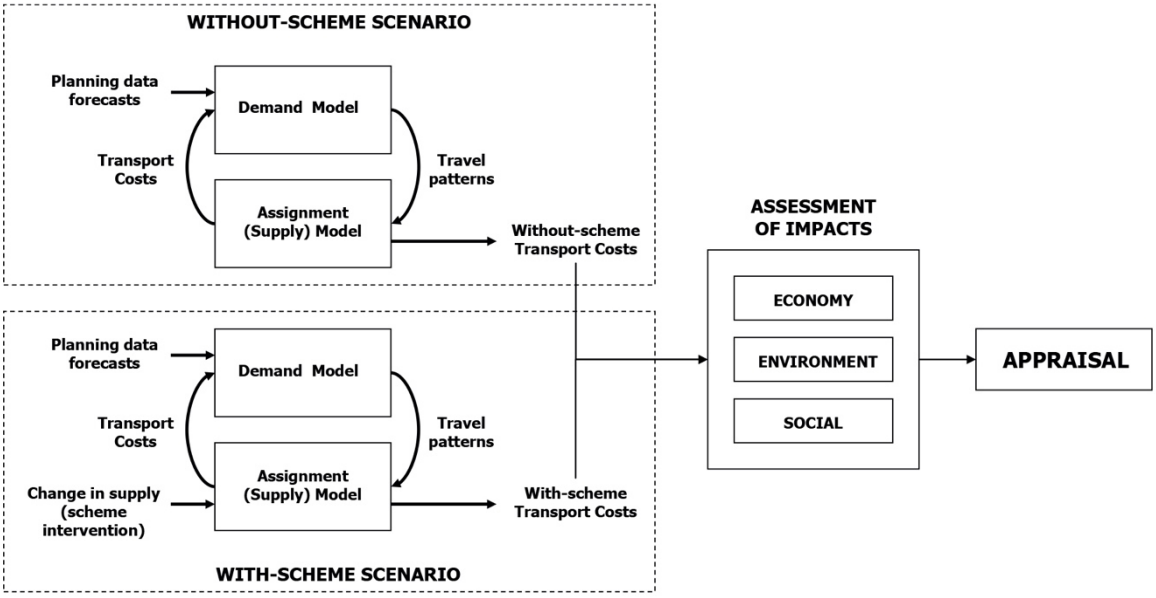

Figure 3.2 Mechanisms of a traditional transport model

3.2.5 The demand model is fed with future year planning data, for example population, households and employment, which drive future travel demand. The supply model then provides updated travel costs for individuals, based on this new demand (e.g. more people on the road will cause higher costs for existing road users). Iteration then occurs between supply and demand (e.g. fewer people may drive as a result of more road delays, only for this reduction to then persuade more back on the road.). This occurs until supply and demand are in equilibrium; that is they are stable, i.e. small changes in costs do not cause significant changes in demand and vice versa. This state is known as model convergence.

3.2.6 It is important to achieve convergence since failure to do so will produce misleading results that are no basis for appraisal. In practical terms, achieving convergence to a satisfactory level and in an appropriate manner takes time and skill from modelling practitioners.

3.2.7 After adequate convergence is attained, the output from the supply model may be used in the appraisal for the specific option(s) being tested. The 'without-intervention' case is based on a supply model where no changes have been made above 'business as usual' conditions. The 'with-intervention' case includes the intervention(s) that are being tested. The appraisal uses the model outputs to assess the impacts of the intervention in terms of economic costs and benefits, environmental impacts such as noise and air quality, and social impacts such as severance, accessibility and distributional equity.

3.2.8 Models can also be used to run "what if?" scenarios where changes in assumptions may be tested. This can help in assessing options before a preferred intervention is brought forward. It can also be used to present "sensitivity tests" around the final appraisal results to account for uncertainty that may occur in real life.

3.3 Choice of Modelling Approach

General modelling considerations

3.3.1 Making an appropriate choice of modelling approach is a matter of considering the particular circumstances and requirements of each study and arguing the case for the preferred approach. Bearing in mind all the above considerations, the following paragraphs attempt to show how the arguments for a particular modelling approach should be constructed.

3.3.2 The key questions are:

- what are the nature of the problems at which the study is aimed, what are their likely solutions and the likely transport impacts (direct and indirect) of those solutions?
- how big is the area to be modelled, bearing in mind that the modelled area should cover the area of influence of any likely solutions?
- how many options need to be tested?

3.3.3 In the first instance, the analyst should prepare an outline specification of a fit-for-purpose modelling system. This outline should consider the extent of the study area, the basic model components required, how they should be linked together and the appropriate level of detail. In parallel with, but separate from, this activity, information should be collated on existing models and data. When both strands of work are complete, the specification should be reviewed and developed, taking account of the constraints of timetable and budget and taking advantage of previous work. This development work will feed in to the Appraisal Specification Report, which is discussed later.

3.3.4 Spatially detailed supply (assignment) models are likely to be a firm requirement at the full appraisal stage. The issues of size of modelled area and number of options to be tested need to be confronted. Assignment models of large areas will be costly to develop, given their requirement for detailed data, unless recently collected data are already available.

3.3.5 For assignment models there is inevitable trade-off between the detail in the network and population represented and the accuracy of the results. The detailed area should be wide enough to capture all material impacts of an intervention. For example, upgrading an urban road junction may require only a small model of the immediately affected area whereas an inter-urban highway scheme that may induce strategic re-routing will necessitate a much broader area that potentially captures several urban areas in some detail.

3.3.6 The question which then follows is: what kind of demand model should be used with the supply models? Key considerations are as follows:

- Is a demand model needed at all? If there is sufficient evidence that there will be negligible changes in travel behaviour as a result of the potential intervention(s), a demand model will not be required;
- What choices need to be included? Will potential intervention affect where people might travel to, what mode they will take and how often they travel?
- Which people should be represented? This will depend on the nature of the intervention. If it is very complex, many different types of people will respond differently and this will need to be represented where this impact is material, which has consequences on the data required and the resources to build the model; and
- How coarse or refined should the spatial detail be? Related to the last point, a finer level of detail can exponentially increase its complexity and resource requirements. A level of detail too coarse may not provide accurate enough results for the appraisal.

3.3.7 The question of whether or not a Land-Use/Transport Interaction (LUTI) model is required also needs to be addressed. It is necessary to consider whether the investigation of alternative land-use policies is a matter of key concern or whether there is likely to be significant interaction between transport and land-use strategies in the study area. It may also be necessary if potential transport solutions are likely to cause significant shifts in the scale and pattern of economic activity, including jobs. If these matters are important and more informal methods are not considered to be appropriate, then a LUTI model may well be appropriate. It is worth noting that LUTI models are generally only used at the strategic level. It should also be noted that these are relatively

sophisticated and specialist models that would not be normally expected in appraisals without demonstrating that the results produced are more realistic than more standard methods.

Specification of the Model

3.3.8 The broad principles of model specification and design will be governed by the requirements of the appraisal, as agreed in the Appraisal Specification Report. This is prepared at a stage of early engagement with the Department. This identifies the needs of the appraisal in terms of important impacts to be measured and any considerations of proportionality where a full detailed approach to modelling will be required or where more simplified approaches may be taken that will not impact on the quality of the results. At early decision points it is prudent to design a model so that it may be efficiently modified for the detail required at future decision points rather than redesigned, if the same modelling system is to be used throughout the process.

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

3.3.10 Getting the technical details of this right relies quite heavily on the judgement of the modeller. However, it is important that the functionality of the proposed modelling system meets the needs of the appraisal and of those relying on the output of the model. The modeller should make full use of the documentation available for the project manager and the practitioner which describes tried and tested modelling techniques.

3.4 Expected Modelling Standards

3.4.1 As explained, the maxim governing the acceptability of a model has to be that it is **fit for purpose**. This means that outputs from the model are robust, have sufficient levels of detail to cover the important issues at hand and that the results are reliable, **passing expected criteria as set out in Guidance for the Practitioner.** This section provides the reader with the main requirements that would be expected of models in principle at the full appraisal stage. Guidance for the Technical Project Manager presents the core criteria of models used in transport appraisals in more technical detail for the project manager in charge of a modelling team.

3.4.2 Assignment models are expected to have sufficient detail to adequately simulate the important flows of traffic on the road network and passenger movements on the rail or public transport network. Basic core criteria are as follows:

- The data used in building the network and individual travel movements are sufficiently up-to-date and provides enough coverage;
- The level of spatial detail is disaggregate enough to provide meaningful results;
- The transport network is adequately represented, covering all important flows of people and vehicles, and importantly that the flows on the networks are **sufficiently validated** so that in base-year conditions they represent reality within a certain level of tolerance;
- In achieving acceptable flow validation, the demand input is not unduly distorted so that it departs from observed travel behaviour, as identified from road side interviews or household surveys; and
- A sufficient level of convergence is attained.

3.4.3 Demand models also have criteria that need to be met in order for them to be accepted as fit for purpose. This involves running "realism tests" to ensure that the model is responding to changes within expected boundaries. The key considerations are as follows:

- All necessary elements of choice are covered, and covered appropriately, e.g. omitting a certain type of traveller response, such as the choice of travel destination, must be fully scoped and explained;
- There is enough detail in the model to pick up all the expected changes. This is achieved by segmenting the population into distinct groups that will react differently to a change in transport conditions. For example, separating households by car ownership is often recommended and where tolls are concerned, income levels may also become important;
- There is sufficient spatial detail, so that enough refinement in travel behaviour is possible;
- The input planning data is sufficient and in line with expectations of the Department, using data from the National Trip End Model (NTEM) as a benchmark;
- The model responds in a manner in line with gathered evidence; and
- A sufficient level of convergence is achieved between the demand and supply models.

3.4.4 For the whole modelling system, there is inevitably a trade-off between: (a) segmentation of demand, (b) degree of spatial detail, (c) the accuracy with which equilibrium is found and (d) the time required to run the model. With models of small areas, compromise may well be unnecessary, but with large study areas, treatment of some elements of the model in an approximate fashion may be inevitable if reasonable run times are to be achieved without compromising the robustness of the model results. Note that while TAG generally implies a relatively detailed approach to modelling, it also draws to the attention of project managers and model developers cases where a justification for a simpler approach can be made.

4 References and Further Information

Department for Transport, 2011, The Transport Business Case, Available at: <http://www.dft.gov.uk/publications/transport-business-case/>

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

HM Treasury, Business Case guidance, Available at <https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-governent>

Department for Transport, Transport Evaluation, Available at: <https://www.gov.uk/government/publications/monitoring-and-evaluation-strategy>

Department for Transport, 2017, Guidance on Value for Money, Available at: <https://www.gov.uk/government/publications/dft-value-for-money-framework>

Highways Agency, Design Manual for Roads and Bridges, Volume 11, 'Environmental Assessment'. Available at: http://www.dft.gov.uk/ha/standards/dmrb/vol11/index.htm

Further guidance on modelling and appraisal is available in Guidance for the Technical Project Manager, which gives practical guidance and more detail on the standards expected in appraisal and modelling.

5 Document Provenance

This is a new Unit prepared for the restructured Transport Analysis Guidance.