Department for Transport

TAG UNIT A2.3

Transport Appraisal in the Context of Dependent Development

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Department for Transport

Transport Analysis Guidance (TAG)

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This TAG Unit is guidance for the **APPRAISAL PRACTITIONER**

This TAG Unit is part of the family **A2 – ECONOMIC IMPACTS**

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1.1 Introduction

1.1.1 This Unit provides guidance on assessing the economic benefits generated by transport in the context of dependent development.

1.1.2 Dependent development refers to new development that is dependent on the provision of a transport scheme and for which, with the new development but in the absence of the transport scheme, the existing transport network would not provide a reasonable level of service to existing and/or new users. This has the implication that the development would not be delivered in the absence of the transport scheme.

1.1.3 This Unit sets out the analysis required to reflect the impacts of new housing in the appraisal of transport schemes, and the circumstances where this analysis is likely to be appropriate.

1.1.4 This Unit focuses on dependent development of new housing. Other types of land use development (industrial, retail, commercial and others) can also have an impact on transport and can be dependent on a transport scheme. Much of this guidance is likely to be applicable to other forms of land use. In particular, the need to demonstrate dependency will be equally important for these developments.

1.1.5 In order to aid appraisers and illustrate how the methodology described here should be applied, a simple spreadsheet model, which draws on sub-regional residential land values from the Government's Valuation Office Agency, has been produced. This spreadsheet is not intended to provide values for use in any specific appraisal but rather to demonstrate, with the use of indicative sub-regional and regional land values, how the methodology described here can be applied.

1.2 Overview

1.2.1 Demand for transport is determined by the location and amount of housing, employment, shopping, leisure and other land uses. New housing and other developments can, therefore, have a significant impact on the demand for transport in the surrounding area.

1.2.2 Where some form of transport improvement is needed to support land use development, planning permission is sometimes granted conditional on the developer providing or funding the transport scheme in full. However, in some cases, development may be needed to satisfy national, regional or local requirements, but the developer is unwilling or unable to fund the transport scheme in full. In these circumstances, the transport authority might need to consider funding the transport scheme from public funds.

1.2.3 When appraising transport schemes, forecasts should be constrained to the planning projections (population, households, employment, workers) and trip ends provided in the NTEM data set, available in the TEMPRO software. NTEM combines official projections of population growth, household forecasts, and other projections, to provide a consistent basis for appraisal.

1.2.4 Areas with planned housing growth will have increased trip generation forecast in NTEM. Appraisal methods using the NTEM data will deliver evidence to reflect the transport impacts of new housing developments, although where new development is being considered lags in data flow may mean that NTEM does not reflect local planning. The increased trip generation arising from planned housing growth will usually increase the benefits of a transport scheme.

1.2.5 For many transport schemes, land use developments can be assumed to be independent of the transport scheme and should be included in both the with- and without-scheme scenarios. In these circumstances, the impacts of new housing will be integrated into transport appraisals through existing methods.

1.2.6 However, it is possible that some transport schemes could 'unlock' housing development. That is, the housing development directly depends upon implementing the proposed transport investment. This might be due either to a lack of access to the planned area of development, or to planning constraints arising from an expectation that the surrounding transport network would be rendered over capacity during peak periods were the new development to proceed. This guidance proposes that in these cases the transport scheme and the housing development should be considered as a combined project, with the assessment of impacts combining the impacts of the housing development, including the benefits flowing from additional housing services, with those of the transport scheme.

2 Definitions

2.1 Definition of "New Housing"

2.1.1 The first issue to consider is the definition of the 'new housing'. For the purposes of this analysis, it is recommended that 'new housing' is defined as those new dwellings provided in or after the opening year of the transport scheme.

2.1.2 The NTEM data set constrains new households to the expected numbers of new dwellings provided. Therefore, the additional households projected in NTEM may act as a proxy for new housing. TEMPRO provides household projections from 2006 and for every fifth year thereafter up to 2041. By using the NTEM forecast year closest to the project opening year as the base, this can be used to estimate, in broad terms, the amount of new housing quickly and easily. Planning assumptions will not necessarily be constrained to NTEM zones, and there will be a need a need to identify an appropriate geographical level at which to constrain planning assumptions.

2.2 Definition of "Dependent Development" for Housing

2.2.1 "**Dependent development**" for housing is defined as follows:

New housing[1] is dependent on the provision of some form of transport scheme if, with the new housing, but in the absence of any transport scheme, the transport network would not provide a "**reasonable level of service"** to existing and/or new users.

2.2.2 There is no precise definition of **reasonable level of service**. However, if additional traffic can be accommodated by the network without significant increases in the costs of travel for existing users, then the network can be assumed to be providing a reasonable level of service.

2.2.3 For example, if traffic flows on a road network remain within the 'flat' part of the speed/flow curve, the network should be assumed to be providing a reasonable level of service. Similarly, if there is no crowding on a public transport network, it should be assumed to be providing a reasonable level of service.

2.2.4 This definition of a 'reasonable level of service' implies that new housing is dependent on a transport scheme if, in the absence of any transport scheme, there would be a significant change in travel costs for existing users of the transport network. The definition of a "significant change" in this context does not have a precise definition and assessment application of some judgement will be required for specific situations.

2.2.5 This approach is consistent with the proposition that what is of concern to the transport authority is the transport external costs resulting from the new housing. "**Transport external cost attributable to new housing**" refers to the change in costs (including time, vehicle operating costs and charges) caused to all other transport users on the network by the traffic generated by the new housing. Transport external costs attributable to new housing should also include the change in revenues for

[1] Note that, for later stages of the analysis, it is necessary to know how many new homes are dependent on a transport scheme. Thus, while it is often convenient to consider new housing at the level of a whole housing development, this definition focuses on new homes.

transport providers as a result of additional public transport usage generated by the new homes, changes in the numbers of accidents and changes in environmental conditions (noise, local air quality and so on). Transport external costs are discussed in more depth in Appendix C.

3 Steps in the Process of Assessing Dependent Development Impacts

3.1.1 To assess the benefits of transport schemes that are attributable to unlocking a housing development, the following steps are needed:

Step 1: Determine the quantity of new housing that should be regarded as dependent on a transport scheme;

Step 2: Identify the minimum transport scheme required to restore a reasonable level of service;

Step 3: Assess the transport user benefits of the transport scheme in isolation (that is, in the absence of the dependent housing development);

Step 4: Assess the benefits of the dependent housing development assuming the transport scheme is provided.

3.1.2 Steps two, three and four should only be taken if the analysis in step one confirms that some housing development is dependent on a transport scheme.

3.1.3 The analysis requires four scenarios to be developed, as outlined below. Details of the specification of these scenarios are provided in Appendix B.

- **Scenario A** - without the housing development and without any form of transport scheme;
- **Scenario B** - with the housing development but without any form of transport scheme;
- **Scenario C** - with the housing development and with a transport scheme;
- **Scenario D** - without the housing development but with a transport scheme.

3.2 Step 1: Determine whether new housing is dependent on a transport scheme

3.2.1 This is a key step in the process. **If housing development is not dependent on a transport scheme, then the need for a transport scheme should be considered solely on transport grounds.** There is no need for the complexity and uncertainty associated with appraising a combination of housing development and a transport scheme. In order to accept evidence of dependent development impacts, DfT would require the methodology set out in this Unit to be followed.

3.2.2 The definition of dependency focuses on the impact of housing development on the existing transport network. Housing development may be dependent on a wide variety of other factors, but, for a transport authority the key issue in determining whether a transport scheme is required is the impact of new housing on the current transport network.

3.2.3 This step in the process must achieve two objectives. First, it must determine whether new housing is dependent on the provision of some form of publically funded transport scheme. Then, if dependency exists, the analyst must estimate how many planned new homes are dependent.

Testing for dependency

3.2.4 In practice, transport networks often operate beyond the limits of a 'reasonable level of service', so it is not practical to define specific thresholds for a dependency test. However, it should be possible to form an opinion of whether or not a "reasonable level" is being met, based on readily available

network characteristics. Therefore, this guidance is not prescriptive, but relies on the application of judgement supported by evidence.

3.2.5 To carry out a test for dependency, two scenarios should be considered:

Scenario A - without the new housing and without any form of transport scheme; and

Scenario B - with the new housing but without any form of transport scheme.

3.2.6 In the following, it is assumed that in Scenario A the network provides a reasonable level of service. Clearly if that is not the case then the new housing is likely to be wholly dependent on some form of transport scheme. However, it must be demonstrated that Scenario A does not provide a reasonable level of service before this conclusion can be reached.

3.2.7 Attention should focus on those parts of the network where the new housing is expected to have greatest impact. If, in Scenario B, the network no longer provides a reasonable level of service in those locations, then at least some of the new housing can be assumed to be dependent on some form of transport scheme.

3.2.8 The simplest approach to determining whether the network provides a reasonable level of service is to compare forecast transport demand at key locations with available capacity. This approach is likely to be appropriate where new housing is restricted to a single site. It may be possible to adopt this approach without using a transport model.

3.2.9 However, where the number of new homes is large, and/or new housing is located in a number of different places, and/or the impact on the transport network is complex, this approach may be difficult to apply and interpret. In these circumstances, a transport model and a more detailed assessment of the impact of the development on the network will be needed.

3.2.10 Model runs for scenarios A and B will usually be required. In some cases, it may be impossible to carry out the model run for Scenario B - the model may not converge, for example. **Provided the model is properly specified,** this may be taken as evidence that the new housing is at least partially dependent on a transport scheme.

3.2.11 Comparison of the model outputs for Scenarios A and B will reveal where the new housing has had the greatest impact on the level of service on the network. Dependency testing should focus on those key locations where there are significant increases in traffic flows or passenger loadings.

3.2.12 Increases in traffic flows on highway networks will usually result in increased travel costs. To demonstrate dependency, increased travel costs in key locations affected by new housing must be exceptional, demonstrating that the network has reached a critical point. The analysis should examine link transit times and junction delays in those key locations. If link transit times have increased sharply, or if significant junction delays have emerged, this may be taken as evidence of dependency.

3.2.13 It may be helpful to calculate the transport external costs for links at key locations in the network – for details of how to do this, see Appendix C. Transport external costs (or transport external costs per existing transport user) will reflect the size of the housing development and its impact on existing users.

3.2.14 Where housing development is expected in a number of locations, it cannot be assumed that all of the new housing is dependent. Further analysis is required to determine which housing development is dependent and which is not. Housing developments that contribute only a small number of trips to the flows at key locations may be assumed to be not dependent on a transport scheme. To understand why this is so, consider the impact of a housing development in isolation, rather than as part of a package of developments. If its impact at the key location is small, it should be assumed that it is not dependent on a transport scheme at that location.

3.2.15 The next step is to explore whether a reduced level of new housing could be accommodated on the network without some kind of transport scheme. This will allow for an estimate to be made of the number of new homes tha may be assumed to be dependent on some form of transport scheme. This analysis may be carried out using a trial and error process, reducing the number of homes (and hence the number of trips generated) and repeating the dependency analysis discussed above until a level of new housing is found that does not lead to an unacceptable level of service on the transport network. Where housing developments are expected in a number of locations, those housing developments that have been demonstrated to be not dependent on a transport scheme should not be included in this analysis. It should, however, be included in the background pattern of housing development (i.e. assumed to be present in both Scenarios).

3.2.16 This analysis should have resulted in an estimate of the number (and, where multiple housing development locations are being considered, the location) of new homes in the housing development(s) that are dependent on the provision of a transport scheme. All other new homes should be included in the background pattern of housing development. Scenario A may, therefore, be revised to include these new homes and used with Scenario B to calculate, for the entire network, the transport external costs attributable to the dependent new homes. This result will provide a useful benchmark for the transport external costs associated with the transport scheme.

3.3 Step 2: Identify an appropriate transport scheme

3.3.1 The analysis carried out in accordance with Step 1 should determine whether housing development is dependent on some form of transport scheme, and should provide a good understanding of the location and nature of the problems that need to be addressed.

3.3.2 The selection of an appropriate scheme should take account of the need to resolve dependency as well as the wider aims for the transport scheme.

3.3.3 A key element of the assessment should be to explore whether each transport scheme considered resolves the dependency issue under consideration. To carry out this assessment, a third scenario must be considered for each potential transport scheme:

Scenario C - with the new housing and with the transport scheme

3.3.4 This scenario should be subject to the same tests and analyses as were used in the dependency testing, discussed above. Attention should focus on those parts of the network where the new housing is expected to have greatest impact.

3.3.5 For some transport schemes, this analysis may suggest that dependency has not been fully resolved. There may be good reasons for retaining a scheme that does not fully resolve dependency. For example, if a transport scheme is being developed to address transport related goals, it may not be sufficient to address the needs of new housing as well. In these circumstances, further analysis should be carried out to determine the number of homes that the transport scheme does 'unlock'[2]. Only those homes that would be unlocked by the transport scheme should be used in the assessment of the benefits of the dependent housing.

3.3.6 If a low cost transport scheme can be shown to resolve the dependency, any more costly transport schemes should be tested as increments to the low cost transport scheme. The incremental analysis should assume the low cost transport scheme and the housing development are part of the 'without scheme' transport scenario. A conventional transport appraisal should be used to assess the incremental transport benefits of the more costly transport scheme.

[2] Note that the nature of the dependency test is such that this cannot be done with great precision. For study areas with multiple housing development sites, it may be sufficient to consider only those which sites which are 'unlocked' by the transport development and those which are not. For study areas where there are fewer housing development sites, it will usually be sufficient to consider this issue in terms of broad proportions only – for example, does the transport scheme unlock half or three quarters of the homes.

3.4 Step 3: Assess the benefits of the transport scheme in isolation

3.4.1 This step comprises a conventional transport user benefit assessment, requiring two transport model runs:

Scenario A - without the dependent new housing and without any form of transport scheme; and

Scenario D - without the dependent new housing but with the transport scheme.

3.4.2 Both model runs must be carried out assuming that dependent new housing is not present. This ensures that the principles of transport appraisal are not violated.

3.4.3 Transport user benefits should be assessed using conventional transport appraisal methods.

3.5 Step 4: Assess the benefits of the dependent development

3.5.1 This Unit sets out the approach be used to estimate the benefits of the dependent development. In summary, this is a two part process: estimate the 'planning gain' arising from the dependent new homes; then subtract the net external costs caused by the dependent new homes.

3.5.2 The external costs caused by the dependent new homes may be divided into two parts: those related to the transport system; and the rest that are not related to the transport system.

3.5.3 To assess the transport external costs of the land use development, two transport model runs are required:

3.5.4 **Scenario D** - without the new housing but with the transport scheme and.

3.5.5 **Scenario C** - with the new housing and with the transport scheme

3.5.6 Both runs should employ the same transport network, which should **include** the transport scheme. Both of these model runs should be straightforward to carry out, since both scenarios would result in realistic forecasts of level of service.

3.5.7 An important point to note is that the transport scheme should **reduce** the transport external costs, compared with the without-scheme scenario, and the transport external costs estimated at this stage in the analysis should be less than those estimated in the first (dependency testing) stage.

4 Reporting the Analysis

4.1.1 Each step in the analysis should be reported in the Economic Appraisal Report. For Steps 1 (dependency testing) and 2 (identify appropriate schemes), the report should set out the criteria used in the analysis and the reasons for their choice. It should then set out the impact on the selected criteria of the tests for Scenarios A (without the new housing and without any form of transport scheme), B (with the new housing but without any form of transport scheme), and C (with the new housing and with the transport scheme). This part of the report should conclude by presenting the numbers of homes unlocked by each transport scheme considered.

4.1.2 The analysis in Step 3 should be reported in standard Transport Economic Efficiency (TEE) and Public Accounts (PA) tables.

4.1.3 For Step 4, the number of dependent homes should be reported, together with their hectarage. The report should also set out the existing and residential land values, the value used for the external benefits of undeveloped land and the transport external costs, as well as the net benefit of the dependent housing. Where local values have been used, the report should set out the basis of those values, including evidence that they are significantly different from those recommended by the Department.

Reporting Results in the Economic Appraisal Report

4.1.4 The results from Step 3 should be reported in the Economic Appraisal Report. Note that the results from Step 3 may be based on some 'new housing', but the proportion of total transport user benefits that is attributable to that new housing should not be reported here. The following paragraphs outline the reporting requirements for analyses carried out in line with the guidance given in this section.

4.1.5 The analysis in Step 4 is likely to result in a large estimated value for the benefits of the dependent housing. This is because the surplus of value of land in residential use over land in, (for example), agricultural use, is typically large. This surplus is a major component of the welfare gain to society that arises from a planning decision in favour of residential use.

4.1.6 A transport scheme may play a key role in facilitating development – the dependency test discussed above tries to identify this role. But transport is one of a range of infrastructure items (water, electricity and so on) required to facilitate development. So whilst it may be true that a development would not proceed without the transport improvement, it is likely also to be true that it would not proceed without other infrastructure investments. Thus the benefits of development arise from a planning decision that depends on a package of infrastructure investments. It is not appropriate to attribute all of the benefits of the dependent housing to the transport scheme in isolation.

4.1.7 The benefits of the dependent housing unlocked by a transport scheme should **not** be included in the Analysis of Monetised Costs and Benefits table and thus not be included in estimates of the Net Present Value (NPV), nor in estimates of the Benefit to Cost Ratio (BCR), for the transport scheme. However, these benefits, together with the number of dependent homes unlocked by the transport scheme should be reported in the economic appraisal report. The estimated benefits of the dependent housing unlocked by a transport scheme are considered in the Value for Money Assessment to reach the overall assessment of Value for Money of the transport scheme.

4.1.8 A qualitative assessment score should be reported depending upon the estimated value of the benefits of the dependent development unlocked by the transport scheme and should follow the guidelines in the following table:

Table 1 Suggested qualitative assessment scores

Benefits	Score
Greater than £100m	Large beneficial
Between £100m and £25m	Moderate beneficial
Between £25m and zero	Slight beneficial
Zero	Neutral
Between zero and -£25m	Slight adverse
Between -25m and -£100m	Moderate adverse
Less than -£100m	Large adverse

5 References

CLG/DfT (March 2007) Guidance on Transport Assessment

CLG (formerly ODPM) (October 2004) Valuing the External Benefits of Undeveloped Land

(DfT, 2006) TEMPRO Planning Data Guidance Note

Meen, G. (2005) "On the Economics of the Barker Review of Housing Supply", Housing Studies 20(6): 949-971

6 Document Provenance

This guidance document has been developed from the content of WebTAG Unit 3.16D, Appraisal in the Context of Housing Development, which was published in January 2010.

Appendix A Assessing the impacts of housing development

A.1 Introduction

A.1.1 This Appendix provides an approach to valuing the impacts of that housing development that has been identified as dependent. Also, practical guidance is provided on the use of a simple spreadsheet model that is published alongside this Unit to show how this valuation approach can be implemented.

A.1.2 Note that this Appendix lists all impacts of housing development. But the following discussion of estimation of those impacts covers only those that do not relate to transport.

A.2 The approach to valuing impacts of housing development

A.2.1 The value to society of a planning decision to grant permission for new development may be separated into two elements:

i) the **private benefit** associated with the change in land use, as represented by the uplift in land value arising from the decision to grant planning permission for that development. This uplift is defined as the value of the land in its new (in this case residential) use minus the value of the land in its existing use (e.g. agriculture), and it typically accrues to landowners.

ii) **net external impact** of the resulting development, including:

- the loss or gain in amenity value of land compared to its existing use;
- transport-related external costs (see Appendix C).

The equation below summarises:

Net private value of housing = Residential land value [1] – existing land use value [2]

Net social value of housing = net private value of housing + net external impact of housing development [3][3]

A.2.2 The release of new land for development reduces the scarcity of residential land, and so reduces the value of existing residential land. This reduction in value should be regarded as having purely distributional effects – there is a transfer from the asset-rich who lose out from new development, to the asset-poor, including non home-owners, who gain. These distributional effects are difficult to estimate, but the valuation approach recommended above is not affected.

A.3 Defining the area of dependent development

A.3.1 The area of dependent development should include only those site areas which will be developed for housing and directly associated uses, including access roads within the site, private garden space, car parking areas, incidental open space and landscaping and children's play areas, where these are provided.

[3] External impacts will usually be costs, thus the net social value will usually be lower than the net private value of housing. Whilst the net social value of housing is expected to be positive in the majority of cases, there may be cases where the uplift in land value arising from the planning decision is low or negative, and/or where externalities arising from development are substantially negative, yielding a negative net social value.

A.4 Non-transport infrastructure costs of development

A.4.1 A range of non-transport infrastructure is required to facilitate new development, including water, sewerage and electricity connections. The impacts of granting planning permission may be attributed jointly to the land use development and any accompanying infrastructure improvements, including those relating to transport. It would not be appropriate to ascribe the impacts to the development, or to the transport scheme, in isolation.

A.4.2 Note that costs of infrastructure (including affordable housing), whether borne by developers or by the exchequer, do not affect the overall valuation of the change in land use outlined above. However, the incidence of infrastructure costs does have distributional effects – to the extent that developers contribute towards these costs, we would expect the costs to be 'passed back' to landowners in the negotiated price of undeveloped land, so reducing the surplus that otherwise accrues to landowners on the grant of permission.

A.5 Using the valuation model

A.5.1 The model allows the user to estimate the value of a housing development that has been identified as dependent upon a given transport scheme.

A.5.2 Below is a discussion of the three key elements of the model, including the data inputs and underlying assumptions. Note that a number of data inputs must be specified by the user on a case-by-case basis as they relate to the nature of the development in question – as such, these data are required of scheme promoters.

A.6 Residential land value [1]

Residential land value = hectarage of dependent housing × residential land value per hectare

A.6.1 Users must calculate the hectarage of dependent housing. The total value of the land in planned residential use is then estimated in the model by multiplying that hectarage by a per hectare residential land value. Here, the model draws upon sub-regional per hectare residential land values provided by the Valuation Office Agency (VOA)[4].

A.6.2 VOA's published residential land values should be regarded as illustrative, and represent typical levels of value for sites for development, in that they have the following conditions:

- no abnormal site constraints;
- a residential planning permission of a type generally found in the area;
- services to the edge of the site.

If planning permissions in the location generally include an element of affordable housing, that will also be reflected in the land values to the same extent as the market would do so.

A.6.3 VOA's reported land values should be regarded as being at market prices (i.e. gross of indirect tax). Therefore it is **not** recommended that the values be scaled up by an indirect tax correction factor.

A.6.4 In practice, land values vary substantially on a site-by-site basis, given differences in, for example, proximity to amenities or density of development. Users are therefore encouraged to draw upon alternative sources of evidence to inform estimation of land values in areas of dependent development. In light of the volatility of land values over the economic cycle, it is recommended that values be averaged over 3 years.

[4] See VOA's **Property Market Report 2011** at https://www.gov.uk/government/publications?departments%5B%5D=district-valuer-services-dvs

A.7 Existing land use value [2]

Existing land use value = {hectarage of dependent housing × (per hectare) value of land in industrial use} + {hectarage of dependent housing × (per hectare) value of land in agricultural use}

A.8 Net external impact of housing development [3]

Net external impact of housing development = {hectarage of dependent housing × (per hectare) external impact of development + transport-related external impact of development

A.8.1 The hectarage of land for development, is also used to estimate the overall value of the external impact of the development.The model draws upon estimates of the external benefits of undeveloped land, reported in Table 7.10 of the ODPM study *Valuing the External Benefits of Undeveloped Land*. The model employs the mean average of the reported estimates of external benefits of 4 types of land: urban fringe (forested land), urban fringe (greenbelt), intensive agricultural land and extensive agricultural land. The model uses In Perpetuity values that are obtained from the ODPM study, updated to 2010 prices and values.

A.8.2 In practice, the external impacts of development are often highly locationally specific – they will vary substantially on a site-by-site basis. Users are therefore encouraged to draw upon alternative sources of evidence to inform estimation of external impacts of development.

A.8.3 As noted earlier, there is a further external impact of development to be considered in the overall valuation - the transport-related external impacts of development. These should be added to the non-transport-related external impacts discussed above – guidance on estimation can be found in Appendix C.

Appendix B Modelling the Four Scenarios

B.1 Introduction

B.1.1 It is important to ensure that the model runs for the dependency test (step 1) are correctly specified and carried out. The following paragraphs outline some of the issues to be considered.

B.1.2 The dependency test requires the comparison of two scenarios:

Scenario A – without the housing development and without any form of transport scheme; and

Scenario B – with the housing development but without any form of transport scheme.

B.1.3 The Department recommends that both scenarios be modelled using standard modelling methods. In particular, the trip end growth constraints dictated by TEMPRO should be met and variable demand modelling should be used where appropriate. Where non-standard approaches are proposed, analysts should discuss this with the Department.

B.2 Modelling Scenario A

B.2.1 The key issue to be considered when modelling scenario A is how to apply TEMPRO trip end growth factors.

B.2.2 Scenario A requires selected housing developments to be omitted. On the face of it, this suggests that the NTEM growth factors cannot be applied. However, analysis has shown that a major part of new household formation (and hence the demand for new housing) comes from existing households. Moreover, net immigration and longer distance internal migration are relatively limited, compared to within region migration. See, for example, "On the Economics of the Barker Review of Housing Supply" (Meen, G, 2005).This suggests that, although the number of dwellings and households in this scenario may be less than specified in NTEM, the numbers of people and, to a first approximation, the numbers of trips made, will be as specified in NTEM.

B.2.3 Thus, the Department recommends that the NTEM trip end growth factors be used without making any adjustment for the omitted homes when modelling Scenario A.

B.3 Modelling Scenario B

B.3.1 The first step is to explicitly model each housing development that is expected to have a significant impact on level of service on the transport network and thus is likely to be dependent on a transport scheme. Briefly, the recommended approach is to model the number of trips generated by the housing development, then reduce the trip end growth factors to be applied to the non-development trips.

B.3.2 The area over which these adjustments should be applied must be considered carefully. For small development it may be appropriate to apply the constraints at district level or similar. However, for larger developments or groups of developments, as may be found in housing growth areas, a wider, sub-regional level may be appropriate.

B.3.3 A key issue to consider when modelling scenario B is whether variable demand modelling is needed. The Department recommends that the usual standards should be applied: if a fixed matrix analysis suggests that the housing development significantly increases network congestion, variable demand modelling of some sort should be applied. The application of variable demand modelling may suggest that the traffic generated by the housing development can be accommodated on the network. In that case, the housing development is not dependent and the appraisal of any transport scheme may follow standard guidelines, taking scenario B as the 'without scheme' scenario.

B.3.4 It may be argued that the application of variable demand modelling means that the new housing is imposing costs on existing transport users. This may be true, but is irrelevant. Growth in the number

of households over time and its impact on user costs in the 'without scheme' scenario is an integral part of forecasting for standard scheme appraisal. Provided the overall level of service remains satisfactory, some increase in costs to existing users is acceptable. This guidance is intended to address circumstances, where specific, localised housing developments result in an unacceptable – and therefore unrealistic – level of service on the network.

B.4 Modelling Scenarios C and D

B.4.1 Modelling for scenarios C and D should follow standard modelling procedures. In each case, the analysis must add a transport scheme to the appropriate 'without scheme' network. Scenario C should build upon scenario B, with scenario D building on scenario A.

Appendix C Transport External Costs Arising as a Result of Land Use Development: Technical Theory and Detail

C.1 Principles

C.1.1 Most land use developments give rise to journeys on transport networks. These journeys are usually regarded as 'new' journeys (though, in reality many will have been diverted from other locations). These new journeys take place on transport networks already being used by other, 'existing' users. Thus they exacerbate current congestion, crowding and so on, leading to increases in costs (including journey times, the money costs of journeys,. unreliability, crowding and so on) for existing users. These increases in costs are termed the transport external costs of land use development. Transport external costs are an important consideration in the analysis of land use developments that are dependent on (i.e. cannot proceed without) transport schemes.

C.1.2 These costs can be estimated using the principles of marginal external costs. In that context, marginal external congestion cost is the change in costs (including time, vehicle operating costs and charges) to users of a given link in the transport network as a result of one additional - or 'marginal' - vehicle on the link.

C.1.3 In the context of land use development, we can consider the marginal change in costs imposed on existing users of the transport network as a result of one additional trip generated by the development.

C.1.4 The transport external costs of a land use development can be estimated using the following equation (the derivation of this equation is set out at the end of this Appendix):

$$TEC = \sum_{ij} (c_{ij}^{1} * t_{ij}^{1} - c_{ij}^{0} * t_{ij}^{0}) - \sum_{ij} c_{ij}^{1} * t_{ij}^{D}$$

where c_{ij} and t_{ij} are, respectively, the cost per trip and the numbers of trips between zones i and j. The superscripts 1 and 0 denote the with and without land use development scenarios and the superscript D denote the matrix of trips generated by the development.

C.1.5 The transport external costs of a land use development can also be estimated on a link basis. This formulation may be useful in establishing dependency. The following equation should be used:

$$TEC_L = c_L^{1} * (f_L^{1} - f_L^{D}) - c_L^{0} * f_L^{0}$$

where TEC_L, c_L and f_L are, respectively, the transport external costs, the link transit costs and the link flow for link L. TEC_L may be summed over all links in the network to give:

$$TEC = \sum_L TEC_L$$

C.2 Theoretical considerations

C.2.1 The transport external costs of a development can readily be calculated using results from a conventional transport model. Model runs for two scenarios are required (both scenarios must be based on the same transport networks):

- a scenario without the land use development, providing the matrices c_{ij}^{0} and t_{ij}^{0}; and
- a scenario including the trips generated by the land use development, providing the matrices c_{ij}^{1} and t_{ij}^{1}.

C.2.2 The matrix t_{ij}^{D} of trips generated by the development will usually be estimated separately from the model itself, then added to a matrix t_{ij}^{E1} of existing trips to generate the matrix of trips t_{ij}^{1} input to the 'with land use' scenario modelling. In most cases, the requirement to constrain overall trips to NTEM will mean that the matrix tijE1 will not be equal to tijE0. Note also that the matrix tijD will only contain non-zero entries for those origins and destinations where land use development trips are generated.

C.2.3 The costs cijo and cij1 for each scenario should be based on the same values of time, vehicle operating cost models and so on as are used in the application of any associated transport appraisal.

C.2.4 It is important to note that TEC may be positive (implying that the land use development imposes costs on existing users) or negative. In particular, negative values may arise as follows:

- If trips generated by existing land use take place on congested parts of the transport network; and
- Trips generated by the development take place on uncongested parts of the network; and
- The application of NTEM constraints reduces the number of trips generated by existing land use; the result may be
- A reduction in congestion in congested parts of the network.

C.2.5 Clearly, a negative result is more likely when estimating TEC assuming a transport scheme has been provided. In these circumstances, those parts of the network used by trips generated by the development are likely to be uncongested.

C.2.6 Conversely, if the development is dependent on a transport scheme, then, in the absence of a transport scheme, those parts of the network used by trips generated by the development are likely to be congested. Thus, an analysis assuming the transport scheme is not provided is more likely to yield a positive value for TEC.

C.3 Derivation of equation for estimating transport external costs

C.3.1 Let us define C as the total travel costs in the transport network. We can represent C as:

$$C = \sum_{ij} c_{ij} * t_{ij}$$

where c_{ij} is the cost of travel from i to j and t_{ij} is the number of trips between i and j.

C.3.2 With the land use development, the number of trips between i and j is the sum of the existing trips, t_{ij}^E, and the development trips, t_{ij}^D

$$t_{ij} = t_{ij}^E + t_{ij}^D$$

C.3.3 We are concerned with costs for existing users only, C^E (note that all trips, whether existing or generated by the land use development, experience the same costs, c_{ij}):

$$C^E = \sum_{ij} c_{ij} * t_{ij}^E$$

C.3.4 The rate of change in costs to existing users as a result of a unit increase in trips generated by the land use development is given by:

$$dC^E/dt_{**}^D = \sum_{ij} d(c_{ij} * t_{ij}^E)/dt_{**}^D$$

where t_{**}^D is the total number of trips generated by the land use development.

C.3.5 At this point it is worth noting that a unit increase in trips generated by the land use development will, in general, affect both the costs for existing users and, as a result of variable demand responses to changes in costs, the numbers of trips made by existing users.

C.3.6 The formulation for dC^E/dt_{**}^D given above takes account of both of these effects. This can be illustrated by decomposing the term $d(c_{ij} * t_{ij}^E)/dt_{**}^D$ as follows:

$$d(c_{ij} * t_{ij}^E)/dt_{**}^D = t_{ij}^E * dc_{ij}/dt_{**}^D + c_{ij} * dt_{ij}^E/dt_{**}^D$$

C.3.7 Here, the term dc_{ij}/dt_{**}^{D} is the rate of change in costs c_{ij} with respect to trips t_{**}^{D} generated by the land use development. This is multiplied by t_{ij}^{E}, the number of trips affected by the change in costs. The term dt_{ij}^{E}/dt_{**}^{D} is the rate of change in the number of existing trips t_{ij}^{E} with respect to trips t_{**}^{D} generated the land use development. This is multiplied by c_{ij}, the cost of each trip affected by the change in trips. Together, these two terms provide the rate of change in cost to existing users as a result of a unit increase in trips generated by the land use development.

C.3.8 The total transport external costs, TEC, arising as a result of a land use development can be estimated by multiplying the rate of change in costs to existing users as a result of a unit increase in trips generated by the land use development, dC^{E}/dt_{**}^{D}, by the total number of additional trips generated by the land use development, Δt_{**}^{D}:

$$TEC = \Delta t_{**}^{D} * dC^{E}/dt_{**}^{D}$$

$$= \Delta t_{**}^{D} * \sum_{ij} d(c_{ij}*t_{ij}^{E})/dt_{**}^{D}$$

The term $d(c_{ij}*t_{ij}^{E})/dt_{**}^{D}$ may be approximated by the following quantity:

$$\Delta(c_{ij}*t_{ij}^{E})/\ \Delta t_{**}^{D}$$

where $\Delta(c_{ij}*t_{ij}^{E})$ is the change in total costs for journeys between i and j resulting from an additional Δt_{**}^{D} trips generated by the land use development.

Hence

$$TEC = \Delta t_{**}^{D} * \sum_{ij} \Delta(c_{ij}*t_{ij}^{E})/\ \Delta t_{**}^{D}$$

$$= \sum_{ij} \Delta(c_{ij}*t_{ij}^{E})$$

$$= \sum_{ij} \Delta(c_{ij}* (t_{ij} - t_{ij}^{D}))$$

$$= \sum_{ij} \Delta(c_{ij}* t_{ij}) - \sum_{ij} \Delta(c_{ij}* t_{ij}^{D})$$

C.3.9 Using superscripts 0 and 1 to denote without and with land use development scenarios, and noting that there are no land use development trips in the without land use development scenario, this becomes:

$$TEC = \sum_{ij} (c_{ij}^{1}* t_{ij}^{1} - c_{ij}^{0}* t_{ij}^{0}) - \sum_{ij} c_{ij}^{1}* t_{ij}^{D}$$

Appendix D Principles Underlying Appraisal of Combined Land Use and Transport

D.1 Appraisal of combined land use and transport

D.1.1 This section provides an explanation of the principle of breaking down benefits into transport benefits (given an assumed land use) plus additional land use / development related benefits.

D.1.2 The objective is to estimate the combined benefits[5] S[T&L] of a transport scheme, T, and a land use development, L, where the land use development cannot proceed without the transport scheme.

D.1.3 In principle, the combined benefits would be estimated by comparing a scenario that includes both land use development and transport scheme with an alternative that includes neither. However, we do not have the tools to allow us to make that comparison. In particular, we know that conventional transport appraisal methods *cannot* be used if land use differs between with and without transport scheme scenarios.

D.1.4 An alternative approach would be to assess the benefits of the two components separately, then combine them. But we cannot simply assess the benefits of the two components in isolation, then add them:

S[T&L] is **not** equal to S[T] + S[L]

where S[T] is the benefit of the transport scheme **without the land use development**, and S[L] is the benefit of the land use development **without the transport scheme**.

D.1.5 Because the land use development is dependent on the transport scheme, the land use development cannot proceed in isolation and hence S[L] does not reflect the true benefits of the development.

D.1.6 However, we can assess the benefits of the transport scheme in isolation, then assess the benefits of the land use development incrementally, adding the two to give:

S[T&L] = S[T] + S[L/T]

where S[L/T] is the benefit of the land use development, assuming that the transport scheme already exists.

D.1.7 S[T] can always be estimated, though the result may suggest that the transport scheme **in isolation** is not good value for money. There is no change in land use between the without- and with-scheme scenarios, so conventional transport appraisal techniques may be applied. In both scenarios the only determinants of demand will be growth and the limitations of the transport network , so there should be no extraordinary inconsistency between network capacity and demand.

D.1.8 S[L/T] - the incremental benefits of the land use development, assuming the transport scheme is already present - can also be estimated satisfactorily. Because the transport scheme is assumed to be present, the problem reduces to that of estimating the benefits of the land use development alone.

D.1.9 Note that the alternative form - S[T&L] = S[L] + S[T/L] - is not acceptable. As discussed above, the land use development cannot be built without the transport scheme, so the benefits of the land use development in isolation are not relevant.

[5] We use the term 'benefits' here to refer to the net present value (NPV) of benefits less costs.

D.2 Benefits of land use development

D.2.1 CLG have developed a methodology for estimating the benefits of land use development based on 'planning gain' arising from the development, PG, less transport and other externalities, TE and OE:

$$S[L/T] = PG - TE – OE$$

D.2.2 The planning gain - PG - arising from the land use development may be estimated by subtracting the value of the land in its 'without development' use from its value in residential use. Note that, because the transport scheme is assumed to have been implemented, the value of the land in residential use will reflect the improved accessibility provided by the transport scheme. However, the benefits S[T] of the transport scheme will not have captured these benefits because it is based on a land use scenario that excludes the land use development L. Thus, there is no double counting across S[T] and S[L/T].

D.2.3 Further discussion of the principles of the benefits of land use change and the practical approach to their estimation are discussed in Appendix B.

D.2.4 The transport externality, TEC, is the additional cost imposed on users of the transport system as a result of the construction of the land use development. The cost can be estimated using a transport model.