



Department  
for Transport

# SUPPLEMENTARY GUIDANCE

## Land Use/Transport Interaction Models

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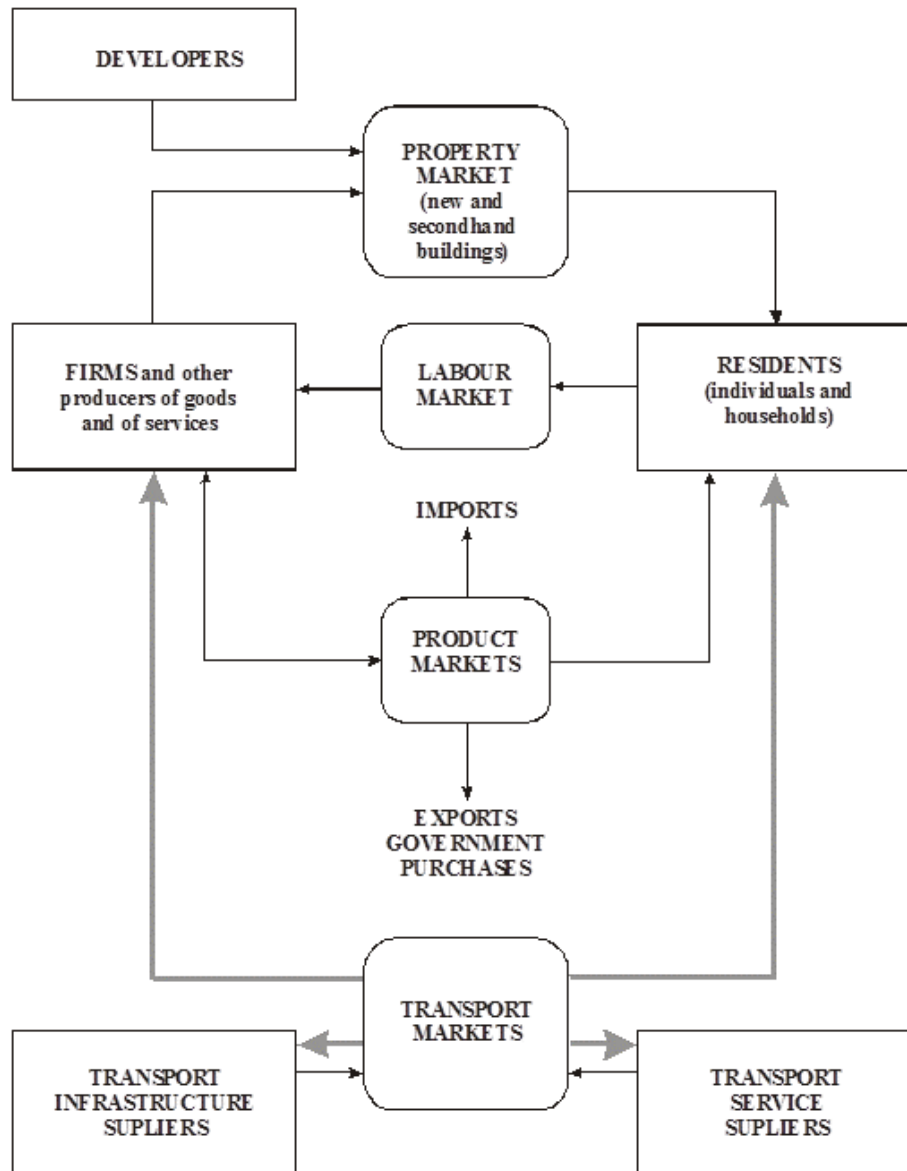
# 1 Introduction to Land Use/Transport Interaction Models

## 1.1 Introduction

- 1.1.1 While a transport model requires inputs of land-use which have been forecast exogenously, land-use/transport interaction, (LUTI) models generate their own forecasts of land-use dependent on input land-use policies and the changes in accessibility brought about by conditions on the transport system.
- 1.1.2 This Unit is limited to providing general introductory principles of LUTI models and is not a practical guide in their development and application. LUTI models are not commonly used in transport studies or appraisals and where examples exist they are predominantly used on a strategic scale. The list of references in Section 2 provides further background information on LUTI models.

## 1.2 The Meaning of 'Land-Use'

- 1.2.1 The term 'land-use' is used throughout this Unit to mean a range of human activities, the state of the built environment, and also to some aspects of the natural environment.
- 1.2.2 Land-use is of relevance to transport for at least three reasons:
- land-using activities and the interactions between them generate the demands for transport;
  - those activities and interactions are to a greater or lesser extent influenced by the availability of transport; and
  - the linkages between transport and activities may be important to the appraisal of transport strategies - especially when trying to consider whether the transport system is providing the kinds of accessibilities that activities (i.e. people and businesses) require, rather than simply providing mobility.
- 1.2.3 Figure 1 illustrates the role of transport in relation to the different groups of people and organisations who are influenced by transport. It identifies three main categories of actors:
- the population, as individuals and as households;
  - firms and other productive organisations; and
  - government.



**Figure 1 Actors and Markets in Land-Use/Transport Interaction Models**

1.2.4 In addition, it identifies three particular categories of actors of special interest:

- property developers,
- transport infrastructure providers, and
- transport service providers (e.g. public transport operators),

which may be special cases either of firms, or of government activity, or both.

1.2.5 The term 'land-use' includes all of the elements and interactions in Figure 1 outside the area labelled 'transport', except for those particular effects which we define as 'environmental'.

1.2.6 Transport influences the decisions of residents and firms in a number of ways, which are considered in more detail below. Residents and firms interact with each other through a number of markets, mainly:

- in property,

- labour, and
- goods and services.

1.2.7 Through these interactions, changes in transport may have indirect impacts on people or businesses. It may therefore be necessary to consider not only predicting the land-use consequences of transport change, but also the implications for appraisal of the way in which the influence of transport is passed on through the interactions of different groups of people and organisations..

1.2.8 Land-use is never static, and transport is only one of the factors that influence how it changes. The treatment of all the other factors - such as demographics, the development process, etc. - are among the things which distinguish the different approaches to land-use modelling.

1.2.9 The following points also need to be noted in order to clarify the scope of the following discussion:

- the land-use impacts of a transport change may extend far beyond the spatial scope of the transport proposal itself - they can extend at least as far as the area in which the transport change affects accessibility, and secondary effects may extend further;
- a great deal of locational change takes place through changing occupation of existing buildings, with changes in either the density or the nature of the occupation (for example, one type of business replacing another, or retired persons occupying housing previously occupied by families with children);
- the value of property is an important influence on its occupation; if improvements in transport increase the demand for space in a particular location, the resulting increases in rents may affect households or businesses who have no direct interest in the transport change itself; and
- it follows from the above points (a) that in many cases changes in composition are likely to be more significant than changes in totals - for example, changes in provision for commuter travel may have a significant impact on where the working population and its dependants live, but a much smaller impact on the distribution of the total population (as households without workers move into the areas that the workers are leaving); and (b) that significant land-use effects may occur within the market for existing property, with no new development and no formal change of use, and therefore beyond the control of the planning system.

1.2.10 It should also be noted that 'regeneration', 'socio-economic impacts' and so on can all be particular cases of what are here referred to as land-use effects.

### **1.3 The Scope of Land-Use Models**

1.3.1 The 'land-use' components of LUTI models cover varying proportions of 'land-use' as defined above. In most cases their representation of the physical use of land is only a small part of the overall model. In some cases, the physical use of land is not considered at all.

1.3.2 A critical aspect in reviewing land-use models is not only to consider what categories of activities they represent, but what kinds of responses of those activities can be predicted - for example, whether households can choose not only to relocate, but also to change the type or size of dwelling they occupy. To begin this discussion, Figure 1 has been expanded so as to identify, in Figure 2, the main types of decisions made by the different categories of 'actors'. An additional category of actors has been added, that of 'investors', in the top right. In the conceptual model, this includes all those investors who may invest in the area under consideration, many of whom are resident outside the area itself.

1.3.3 For clarity, no attempt has been made to show within the diagram that many individuals are in more than one category - for example, self-employed persons are producers as well as residents, and many residents are also investors. One of the most important 'actors', government of all levels, is

omitted, even though its intervention through regulation, taxation and investment is an actual or potential influence on almost all the decisions considered. Much of the development of operational models has been led by the need to consider the impact of such interventions, given the behaviour of all the other actors involved.

1.3.4 In land-use modelling, the location of activities (and in many cases the location of the development they occupy) are outputs of the model, and the models take a description of 'planning policy' as an input; this contrasts with the conventional 'planning data' used in transport-only models, which corresponds with the outputs (e.g. population and jobs by zone) of land-use models.

1.3.5 The lines on the diagram show the major interactions between different categories of actors, classified so as to identify the main 'markets' in factors, goods and services. The directions of the arrows on the diagram are such that:

- the arrowheads show the delivery of a factor, good or service; and
- payment for that factor, good or service goes in the opposite direction to the arrow.

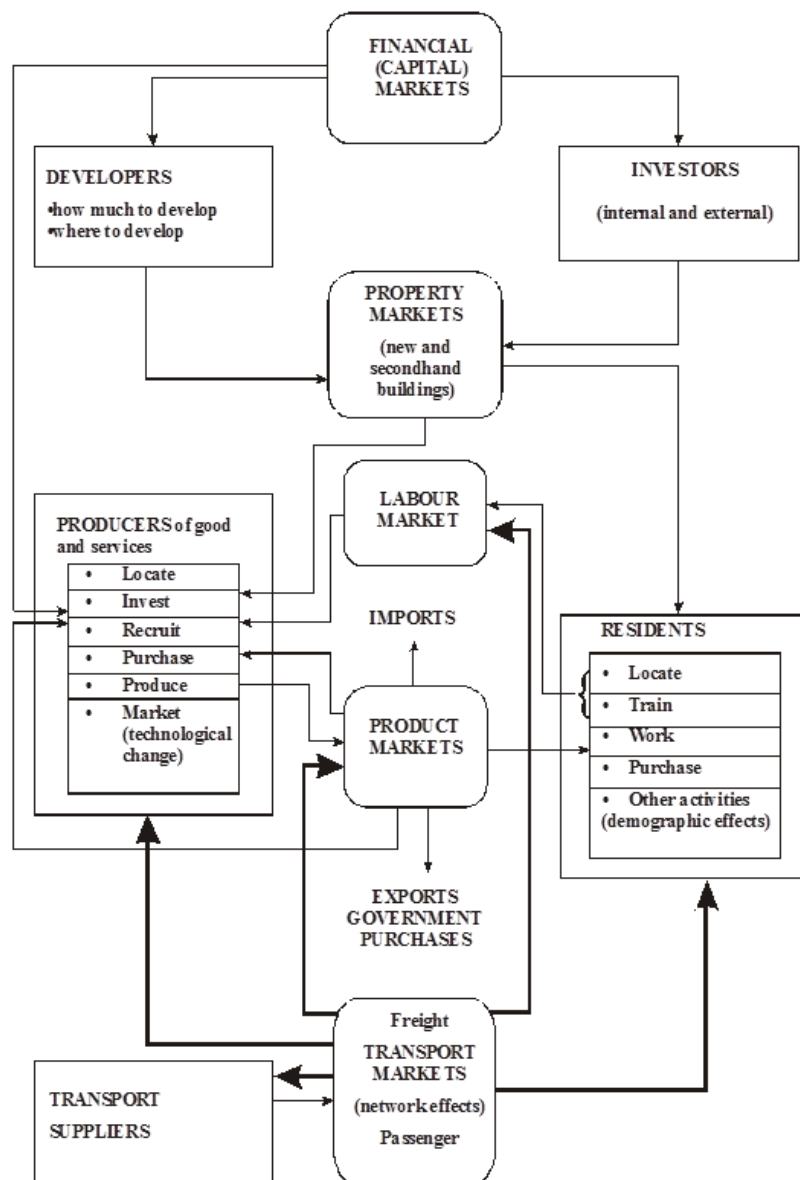


Figure 2 Actors and Markets in Land-Use/Transport Interaction Models: An Expansion

- 1.3.6 Information also flows in both directions along each of the relationships indicated by arrows. This represents the often very partial information which people and firms obtain from the interactions with the market. Other information is obtained in other ways, which may themselves involve purchasing goods and services (e.g. market research reports, special surveys, newspapers with job and property advertisements, etc).
- 1.3.7 The five markets are, from top to bottom of the diagram:
- the financial market(s);
  - property markets;
  - labour markets;
  - product markets (including both goods and services); and
  - transport markets.
- 1.3.8 The first three of these are markets in the conventional factors of production (capital, land and labour), and markets in transport are a special case of the markets in services. No attempt has been made to separate categories of goods and services that are delivered via non-market mechanisms, such as, for example, public (state) education, and there are other whole sub-systems, such as taxation, welfare and benefits, which affect the behaviour of actors. The scope of the diagram as it stands is simply that which seems helpful to the discussion of 'land-use/transport interaction models'. For this discussion, however, the possibilities are included that products may be:
- exported;
  - consumed by the government; or
  - used in fixed capital formation (the arrow from product markets to the 'invest' action of producers); and also that they may be;
  - supplied by imports to the economy under consideration as well as by local production.
- 1.3.9 The bold lines linking the transport market to the rest of the system emphasise that transport is generally a 'derived demand', derived from some other aspect of the economy. In the diagram, the derivation of demands is split into five segments:
- transport demands associated with product markets, that is, with the delivery of goods and services (through the movement of goods and persons, including consumers going to purchase goods or services) to intermediate or final consumers;
  - transport demands associated with labour markets - mainly the movement of persons travelling to work;
  - other travel demands associated with the activities of producers - these represent all business demands, mainly for passenger travel, not directly associated with trade in goods or services (e.g. travel to conferences, to internal company meetings, to meetings with regulatory bodies, etc.);
  - residents' travel demands other than travel to work or to obtain goods and services, i.e. all other personal travel; and
  - transport demands associated with transport supply itself (e.g. the significant proportion of rail freight which is generated by maintenance and renewal of the railway itself).

1.3.10 The bullet points listed under some of the 'actor' headings are general descriptions of key types of decisions that have to be taken by these categories of actors. The conduct of business by producers is generalised into:

- where to locate the business unit;
- investment in the unit - how much to invest, in what equipment;
- recruitment - what categories of staff to employ, how many, for what hours, at what wage rates, etc;
- purchasing - what intermediate goods and services to purchase, from whom;
- production - how much of what to make and when; and
- marketing - which markets to try to sell in, what to do to achieve this, etc.

Many decisions, particularly major ones, will of course deal simultaneously with most or all of these areas.

1.3.11 For residents, activities are classified into five headings:

- where to locate (and hence what land and floorspace to occupy);
- training - what (if anything) to do to obtain/maintain employable skills;
- work - whether or not to work, for whom, doing what, when, etc;
- purchasing - how to spend (or save - note link to investors) income derived from work or other sources; and
- other activities - everything else.

Note that the first three determine each person's involvement or otherwise in the labour market, and hence collectively the 'labour supply', whilst 'labour demand' is determined by the location and recruitment decisions of producers.

1.3.12 The diagram, and the discussion of it, could of course be further elaborated, and it should be emphasised that it is a partial view of the world. As it is currently drawn, attention is drawn to just a few other influences on activities and decisions, indicated in brackets. These are:

- technological progress as an 'exogenous' influence on producers (in the sense that even if firms are technological leaders and innovators in their particular fields, they are strongly influenced by the development of technology in other aspects of the economy);
- natural demographic processes (ageing) and social effects (marriage/cohabitation, separation) on residents and their grouping into households; and
- network effects (congestion) in the transport system (as distinct from the deliberate responses of transport operators and suppliers).

1.3.13 There are of course many models which represent particular processes or effects (such as local demographic change) without relating it to transport. To be of interest to the present studies, a model or modelling package must include:

- some form of spatial representation of producers, residents, and transport supply (not necessarily traced back to transport suppliers);



- links from the transport markets to the activities and markets which use transport, such that changes in transport have at least some impact on some decisions or responses of producers and residents; and
- scope for links from producers and residents, and/or from labour and product markets, to transport markets, as the main or only process by which transport demands are derived.

1.3.14 If it is decided that a particular study needs to model the impact of transport on land use (including economic and social impacts, etc.), there will be two options:

- to apply a simple model which predicts the land-use impact of transport change on the assumed planning data, but does not include the feedback from that land-use impact back to transport; or
- to apply a more complex model which includes both linkages, i.e. a full land-use/transport interaction model.

Note that, in the former simple model case, some other part of the modelling system will need to convert the assumed planning data into future transport demand; in the case of a full land-use/transport interaction model, this will be a central part of the overall model system.

1.3.15 The DSC/ME&P Report to SACTRA discusses the scope of various models, including sketching out their coverage of actors and markets as defined in Figure 2.

#### **Data Requirements**

1.3.16 Data requirements can to some extent be split into two categories:

- data required to implement the model, i.e. the variables which have to be introduced in order to make the model represent the chosen city or region, and which are either **direct inputs** to the working model or **are automatically reproduced** by the working model; and
- additional data or information required to calibrate the model to reproduce the behaviour of the chosen system or the processes at work within it.

1.3.17 Two other types of input also need to be noted:

- the range of inputs which can be used to specify future scenarios; and
- the range of policies that can be tested.

1.3.18 It should be noted that data requirements will depend on the design of each particular model application, and in nearly all cases the model implementation process can be adapted to the availability or otherwise of particular types of information.

1.3.19 In general, the requirements for the implementation category of data are quite firm - there must be one number for each variable in each zone - but at least in the early stages of model implementation there is a lot of scope for choice in the definition of variables (e.g. how many household types, how many employment categories). In contrast, the requirements for calibration are much less precise - although some of the packages have automated calibration routines which require particular inputs, these are not the only way of arriving at the eventual coefficient values. An example of the basic data requirements are:

- Households/ population
- Employment (status of residents)
- Employment (by workplace)
- Floorspace by type

- Rents
- Household incomes
- Matrices of labour to work
- Matrices of goods and/or services to consumers
- Development under construction in base year

## 1.4 The Main Approaches Available

- 1.4.1 The discussion around Figure 1 and Figure 2 has already mentioned that the subject of 'land-use' includes both the location of activities (and various aspects of their behaviour in those locations) and the economic interactions between activities in the various markets. These economic interactions - such as the flow of labour from homes to workplaces, or of goods from producers to consumers - are not generally identical with transport demands, but are clearly closely related to them. There is a close relationship or identity, in many cases, between the measures of economic interaction and certain measures of activity location: for example, the row or 'home' totals of a matrix of labour (measured in workers) flowing from homes to workplaces must equal the number of working residents living in each zone, whilst the column totals of that matrix must equal the number of filled jobs in each zone.
- 1.4.2 Models can be classified according to how they link the location of activities and the spatial interactions between activities. This classification is important both to understanding the thinking behind different models and to practical questions of how they are implemented and used to appraise policies.
- 1.4.3 One approach takes the interactions between activities as the key variables. These are predicted, and then the location of activities is calculated from the total levels of interaction. For example, the number of households living in a zone is found by predicting the number of workers commuting from that zone to each possible workplace, finding the total workers resident, and then factoring from workers to households. The patterns of interaction are also factored, from persons to trips, to give transport demand matrices. This approach may be called the "interaction-location" or IL approach, since the central feature is that the predicted interactions determine the location of activities. Such LUTI models can also be called "integrated" models, since the distribution of transport demand is wholly predicted within the land-use model. This means that the land-use and transport components of the overall model system cannot be separated.
- 1.4.4 The alternative approach first predicts the location of land-using activities, and then models the interactions between those located activities. This can obviously be called the "location-interaction" (LI) approach. This allows the number and location of the different kinds of activities to be determined by separate sub-models. These can consider any appropriate influences, but include measures of zonal accessibility, which reflect the scope for interactions from each zone. Hence, for example, a sub-model for residential location will include measures of accessibility to work and to other destinations. The interactions between activities are then controlled by the location of activities. These interactions may be modelled in economic terms, or may be predicted directly in terms of travel demand.
- 1.4.5 This LI approach leaves the distribution of transport demand at least partly to the transport model. The overall model therefore consists of a complete transport model linked to a land-use model, rather than part of the transport model being embedded within the land-use model. The approach can therefore be described as "linked", in contrast to the "integrated" approach described above.
- 1.4.6 Various points about these alternative approaches should be noted.
- 1.4.7 Firstly, IL or integrated models tend to be defined in terms of finding the equilibrium location and interaction of the different activities considered, given certain fixed variables such as a "basic" or

exporting sector of employment and the supply of land or floorspace. This is necessary because of the way in which the number and location of activities is built up from their interactions with other activities. For example, this approach generally requires that households are “generated” by the demand for their labour, and that demand depends in part on households’ demands for services. This linkage has to be run to equilibrium, otherwise households and jobs will disappear from the system.

- 1.4.8 In contrast, the LI or linked approach need not have any equilibrium between the location and number of different activities – it can for example readily predict an increasing supply of labour in an area of decreasing demand, and the resulting unemployment.
- 1.4.9 Secondly, IL models by definition predict matrices of interactions which can be converted into matrices of the demand for transport. This may be useful in circumstances where observed transport demand data is unavailable or where a synthetic matrix is needed as input to a matrix-refinement process.
- 1.4.10 Thirdly, the fact that LI or linked models incorporate a distinct transport model which represents the complete range of transport-user responses is likely to make it easier both:
- to develop a LUTI model where a suitable transport model already exists, by adding an appropriate land-use element; and
  - to carry out transport-only tests, and hence to produce transport-only calculations of benefits which are currently required as part of the appraisal process.

#### **Modelling Effects, Decisions and Markets**

- 1.4.11 Much of the literature on LUTI modelling is concerned with description and comparison of how the models work - what may be called the ‘model mechanisms’ and the theories or assumptions underlying them. Such presentations do not necessarily make it clear to the non-specialist what connections are made by the models, and how these are made. Chapter 4 of the DSC/ME&P Report to SACTRA tries to remedy this, by summarising:
- what interactions between supply and demand are represented in the transport model;
  - what information is passed from the transport model to the land-use model;
  - what impacts changes in transport have within the land-use model (and whether these are immediate or lagged); and
  - what information is passed back from the land-use model to the transport model.
- 1.4.12 These points represent a useful checklist for gaining an appreciation of any particular model. Another important aspect of understanding is to know which effects within the land-use model are explicitly represented as decisions of particular kinds of ‘economic actors’ (households, firms, etc), or as other appropriate and explicit processes, and which are represented only implicitly by fixed relationships or as being determined by other decisions. Differences in representation cannot generally be described as ‘right’ or ‘wrong’, but particular approaches may well be ‘appropriate’ or ‘inappropriate’ to particular studies: the relationship between economic change and population change, and between both of those and the development process, are points which should be considered carefully.
- 1.4.13 One way of looking at these points is to consider the ways in which different models represent the markets, in labour, in goods and services, and in property.
- 1.4.14 It must, however, be noted at this point that the modelling software in use consists of ‘packages’ which generally offer considerable scope for different applications within one broad approach. The detailed representation of response to transport in non-transport markets could be significantly

different in future application of these packages. There is scope for fine-tuning to the requirements of particular studies, though the constraints on this should also be noted: above all, that the modelling of choices in the 'land-use' system, just like the modelling of choices in transport, is only valid if the set of possible choices is correctly specified. This makes it difficult, and at present largely impossible, to build a meaningful LUTI model for a small area around a scheme, or for a one-dimensional corridor between two places. This difficulty also applies to modelling the distribution of travel.

## **1.5 Land-Use/Transport Modelling and Strategy or Plan Appraisal**

- 1.5.1 It is probably helpful to split the issue of appraisal in relation to LUTI modelling into two subjects: first, the appraisal of transport strategies or plans, with land-use policy held constant, and secondly, the appraisal of alternative land-use policies, alone or in combination with alternative transport strategies or plans. Note that, for the reasons already explained, holding land-use policy constant does not mean that the land-use patterns will remain constant - they may be changed by the effects of the transport strategy or plan.

### **Appraisal of Transport Strategies or Plans**

- 1.5.2 The first point to note is that it is currently not possible to conduct a cost/benefit analysis in which land-use changes feed through into travel demand changes. The reason is that, at present, the way in which land-use responses and transport responses are represented mathematically in LUTI models are not sufficiently consistent to allow the calculations to be undertaken in a manner which accords with the theory on which transport cost/benefit is currently based.
- 1.5.3 The economist's conventional view of the land-use impacts of transport change has been that such impacts change the distribution of costs and benefits - for example, transport benefits initially enjoyed by travellers may be captured by real estate owners through increasing rents - but that they do not modify the total net value resulting. This view would imply that it is not necessary to assess the benefits associated with the land-use impacts at all, because they are simply transformations of the benefits which can be estimated on the basis of a transport-only analysis. There are at least three objections to this view.
- 1.5.4 The first is that the distribution of benefits is often of concern, both spatially and socially. Most governments have policies which are intended (for example) to redistribute jobs to high unemployment areas, and transport investments which support such policies should be regarded as more beneficial than those which work against them.
- 1.5.5 The second is that the view that land-use impacts transform and redistribute transport benefits has been shown to be valid only under conditions of perfect competition (Jara-Díaz, 1986). More recent work (Martínez and Araya, 1998) has shown how unrealistic these conditions are, and has started to show how much the measures of benefit are modified by land-use effects. Whilst it appears highly significant, there is much more work to be done both on the issues it raises about how benefits should be evaluated, and if appropriate to implement suitable methods of benefit calculation within other land-use models.
- 1.5.6 The third, which is perhaps a less formal view of the second, is that if the costs and benefits of a transport scheme change as one expands the scope of the transport analysis, it is implausible that the costs and benefits should not differ further if the analysis is extended into 'land-use' effects. For example, the appraisal of a major motorway project will produce one result if it is based upon a fixed matrix of person-trips by road, but a different result if modal choice is taken into account and public transport operator response to changing demand is taken into account (e.g. if transfer from rail to road will lead to a decline in rail services). It is hard to see why further extension to include location and development effects would not lead to further modifications of benefit, especially when one notes that the location effects may be influenced by environmental externalities as well as by (variables derived from) the generalised cost of transport.

- 1.5.7 At present, there appear to be two approaches to appraisal in LUTI modelling practice.
- 1.5.8 One effectively ignores the issues identified above, and carries out a relatively conventional transport-only calculation of benefits (based primarily on time and money savings) by testing the alternative transport strategies with land-use held constant. This could be extended by carrying out the test under both the reference case land-use pattern and the modified land-use pattern resulting from the land-use impacts of the strategy being tested; this would show whether benefits increased or decreased as land-use responded. Neither of these sets of calculations would yield the net benefit arising from the combined effect of the transport strategy and the resulting land use response nor would it tell us how the land-use effects would redistribute benefits.
- 1.5.9 However, it is possible to examine the predicted land-use effects and to include separately in the appraisal any impacts which are identified as being particularly desirable or undesirable. Desirable impacts would include regeneration (however defined, e.g. new development, new jobs, or reduced unemployment) in areas where that is a policy objective; undesirable impacts could include very much the same effects in areas where they are considered undesirable (e.g. increased demand for housing and associated pressure for development in National Parks or AONBs).
- 1.5.10 At the other extreme, at least one modelling package attempts to carry out a comprehensive appraisal of benefits in the land-use system. This does respect the requirement to take land-use effects into account, as outlined above. This, of course, produces measures of benefit different from those in transport-only analysis; it should include the benefit (or disbenefit) that households or firms obtain from paying different levels of rent, from living at lower or higher densities, from being in different (e.g. more or less attractive) locations, and so on. This clearly goes well beyond a conventional transport cost/benefit analysis, however desirable such an extended analysis is, it may come up against the institutional or administrative problems because it is unfamiliar and difficult to relate to the analyses from more conventional models.
- 1.5.11 Such analysis also raises more technical complications in terms of dealing with the lagged responses to transport in most land-use models. It is no coincidence that the most advanced application of the analysis of both land-use and transport benefits within a land-use model is based upon a system in which the land-use and transport systems are calculated so as to be in complete equilibrium with each other. The more sophisticated the dynamics of the land-use modelling, the more complicated it will be to establish sensible measures of benefit calculated within the land-use system.
- 1.5.12 There is also an issue of the assessment of environmental effects. In some land-use models, residents (and potentially firms) are influenced in their location decisions by the environmental impacts of transport. Negative transport impacts (e.g. increases in noise and in local air pollution) would decrease the willingness to pay to live in the locations affected, and would generate disbenefits (e.g. to the owners of property in those locations). This might start to duplicate environmental impacts which have conventionally been considered as separate parts of the overall appraisal process.

#### **Appraisal of Land-Use or Combined Land-Use/Transport Strategies**

- 1.5.13 A major attraction of the comprehensive appraisal of benefits (including the benefits derived from transport) in a land-use model is that such an approach should in principle be able to carry out a consistent appraisal of any combination of land-use and transport elements. This needs to be considered not only as an extension of transport strategy appraisal, but also in terms of its possible role in the land-use planning process.
- 1.5.14 The idea of a consistent, combined appraisal of land-use and transport choices has a theoretical appeal, and should help to ensure that the wider objectives of land-use planning are not made subordinate to the narrower objectives of transport planning. However, it is beyond the scope of the current practice, and therefore this Guidance, to investigate the complexities of assessing costs and benefits in this area. It is, however, appropriate to note that existing land-use models can provide a

wide range of indicators (not just transport indicators) about the impact of alternative land-use strategies, alone or in combination with transport strategies. These indicators are the kind of information expected by current approaches to assessment in both fields of planning, under headings of 'regeneration' or 'socio-economic impacts' as well as 'land-use' itself.

### Scope for Testing Land-Use Policies

- 1.5.15 The abilities of land-use models to test land-use policies depends very much upon the details of the particular application. It is also difficult to define the policy-testing scope even of a specific model; as with the more elaborate transport models, there is generally a set of policies which can be 'directly' modelled by inserting or changing numbers in pre-defined fields, and a larger set of policies which can be less directly modelled, by some form of intervention in the operation of the model or with the addition of an additional set of calculations. Table 1 below attempts to indicate a typical set of capabilities for an 'urban' model and a 'regional' model, under the conventional headings of regulation, pricing and investment.

<b>Table 1 Typical Policy Testing Capabilities of Land Use Models</b>		
<b>Policy intervention type</b>	<b>Examples in urban modelling</b>	<b>Examples in regional modelling</b>
Regulation	Allocation of land to development (by zone, by development type, by year) Permitted density of development Maximum density of use of space	
Pricing	Taxes/subsidies to development Taxes/subsidies on occupation of property	Taxes/subsidies on production
Investment	Exogenous development (i.e. exogenously defined additions to building stock) Redevelopment (i.e. exogenously defined reduction in the building stock, followed by development) Exogenously added (or subtracted) activities, e.g. major new employers or closures Investment in utilities may be a prerequisite to new development	Exogenously added (or subtracted) activities, e.g. major new employers or closures

Notes:

- 1 the table lists only land-use strategy components; the scope for testing transport strategies is determined by the associated transport model
- 2 the model operation is generally the same whatever strategies are being tested, i.e. the introduction of policy variations changes the quantitative results of the model but does not require different modules or processes to be applied.
- 3 Combined urban/regional models are possible.

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Notes to the references.

The book edited by Webster et al (1988) is commonly referred to as “the ISGLUTI Report”, but covers only the first phase of ISGLUTI’s activities. The second phase, which involved applying several models to each city, was reported in a series of papers in *Transport Reviews*, concluding with that by Paulley and Webster (1991).

A number of papers on urban and regional modelling, originally delivered at the Martin Centre 25<sup>th</sup> Anniversary Conference, 1992, were published in Volume 25 number 5 of *Environment and Planning B: Planning and Design*. These included papers on the design and calibration of MEPLAN-based urban models (Williams, 1994 and Hunt, 1994, respectively) and regional models (Rohr and Williams, 1994) and experience with the TRANUS model in Venezuela (de la Barra, 1994), as well as a paper on the strengths and weaknesses of the Martin Centre modelling approach by Simmonds (1994). The issues covered in the last of these formed part of the background to the subsequent development of the DELTA package.

### **3 Document Provenance**

This Unit is based on former TAG Unit 3.1.3 – Land-Use / Transport Interaction Models (June 2005), which was itself based on Appendix B of *Guidance on the Methodology for Multi-Modal Studies Volume 2* (DETR, 2000).