DISTILLATE

Deliverable F2 : Review of modelling capabilities

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Project F: Enhanced analytical decision support tools

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1 Introduction

Research for the Department for Transport and for the EC and our own scoping study discussions have indicated that a substantial proportion of local authorities do not use models for strategy formulation or scheme design and appraisal, and that others who do are doubtful of the value of the models which they use. These situations arise for a number of reasons: most models are unable to reflect the range of policy instruments which local authorities now use; model predictions often appear unreliable; models are often too complex for local authority staff and stakeholders to use themselves; and as a result models are typically run by consultants and treated as black boxes by local authorities. Project B will be developing new approaches to strategy generation and scheme design; Project D will look at how models are used (and misused) in the planning process, and this project will build on this to identify ways of increasing the beneficial use of currently available models. In this project we intend to develop *low cost enhancements* to existing models to build on the work of Projects B and D. We intended to focus on three themes: the lack of coverage of policy instruments, the need to enable a wider and more effective use of models and the need for enhanced strategy generation tools.

To recap, the overall objective of this project is to enhance existing predictive transport and land use models so that they can be used more effectively and intensively by local authorities and other stakeholders. Within this overall objective, the project had the following more specific sub-objectives to:

- Identify those policy instruments which could most usefully be incorporated into existing models and to develop and test ways of doing so
- Enhance existing sketch planning models so that they can be used more effectively and interactively by a wider range of stakeholders
- Develop our sketch planning models and network management design tools as pilot strategy and scheme generation tools.

The first sub-objective was tackled through the initial survey of local authorities and as explained below the results threw up general areas of concern regarding model capabilities and use rather than an exhaustive list of instruments which should be incorporated into existing models. We responded to this by adapting our review process and re-structured not around instruments but around the themes identified from the survey. This in turn had implications for the choice of case studies which are described below with reference back to the identified themes.

1.1 Aims of the report

This is the first public report from project F. The aim of this report is to summarise the key issues of concern regarding modelling identified in the initial survey, to summarise the literature reviews conducted in response to these concerns and other issues arising from projects within DISTILLATE; and finally to demonstrate the links between these issues and the case studies to be conducted with our models.

1.2 Structure of the report

Section 2 summarises the results of the survey and identifies the key themes for the rest of the report. Section 3 summarises the themed reviews with full details available as appendices. Section 4 discusses other issues raised during the survey and arising from discussions within DISTILLATE. Section 5 describes the case studies by model and section 6 outlines the future reporting structure for the case studies.

2 Summary of the survey results

This section gives a brief summary of the outputs (related to modelling) from the questionnaire administered by Project A. The aim of this part of the survey was to interrogate authorities on the importance they attached to the modelling of different proposed interventions, and their perceived abilities and/or barriers in doing so. The compositions of model outputs for different policy instruments in terms of behavioural responses were also reviewed. A full analysis of the survey is available from Project A (DISTILLATE (2005)).

The most useful answers (apart from the individual text box answers) came from the *importance* and *satisfaction* questions about the different types of policy instruments and enabling factors.

Figure 1 summarises the importance given to modelling certain types of policy instruments. In general LRT, Land use measures, road infrastructure, traffic restraint and improvements to bus services were seen to be most important while slow modes, information provision, traffic management and soft measures such as awareness campaigns were seen to be less important in terms of modelling by some authorities.

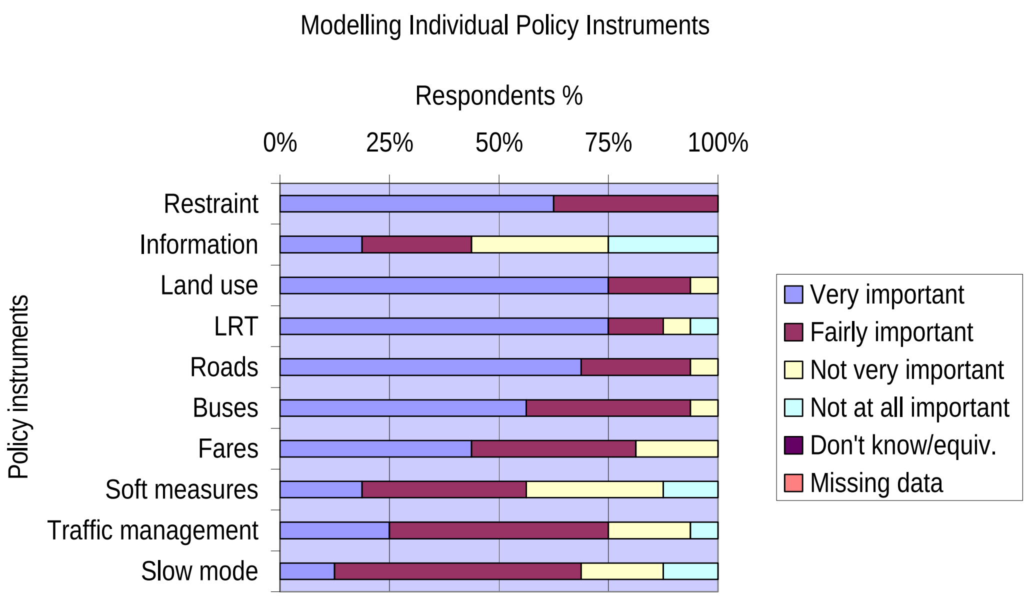


Figure 1 : The importance of modelling specific types of instruments.

Figure 2 summarises the level of satisfaction with their ability to model the same instruments. In general most authorities are satisfied with the modelling of LRT, new road infrastructure and traffic management and to some extent land use measures.

The level of satisfaction for other measures will depend partly on the measure being considered but also on the experience of models used by each local authority.

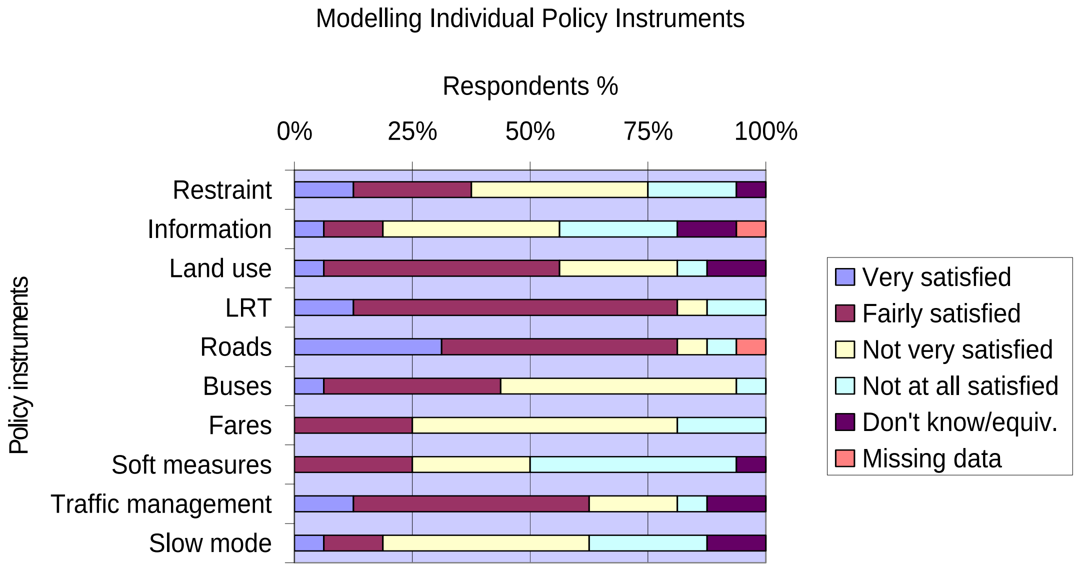


Figure 2 : The level of satisfaction for modelling specific policy instruments

Table 1 combines these importance and satisfaction scores. A similar analysis is presented for *enabling* factors. The scores give the following ranking of barriers by instrument type and for other *enabling* factors. A higher score implies that the instrument type or enabling factor is important and has most room for improvement.

Ranking of Modelling issues	Combined satisfaction importance Score (0-1)[1]	Ranking of modelling needs	Combined satisfaction importance Score (0-1)
Restraint	0.58	Staff	0.63
Fares	0.55	Resources	0.63
Buses	0.53	Data	0.56
Land use	0.53	Outputs	0.50
LRT	0.47	Capability	0.50
Soft measures	0.43	Institutional	0.48
Slow mode	0.42	Customisation	0.42
Roads	0.41	Guidance	0.38
Traffic management	0.36		
Information	0.34		

Table 1: Ranking of modelling issues and enabling factors.

From the above ranking and more detailed analysis of the questionnaires it was decided that the project should look at the following modelling themes :-

[1] Note: The neutral score is 0.3175. Higher scores indicate a barrier. Score 1.0 would indicate Very important and not at all satisfied for all respondents.

1. Demand restraint measures – better modelling of responses
2. Public Transport improvements
3. Land use measures
4. Soft measures (attitudinal)
5. Slow modes and small scheme impacts

and more general issues

6. Data issues
7. Model use

Note that within project F we concentrate on model enhancements or methodology in 1-5. For modelling needs we recognise that staff expertise/training and resources are the most problematic barriers – but that this project is unable to look at these issues. Instead we intend to look at data issues and model use which includes natural links to other projects within DISTILLATE and to our other sub-objective in F of enhancing use of existing sketch planning models.

As noted earlier the responses to the survey did not come up with a list of specific policy instruments which should be incorporated into models, though some do fall into this category e.g. some of the soft measures such as travel awareness campaigns, instead we ended up with a set of themes where modelling of current instruments was seen as important yet there were still relatively low levels of satisfaction with current modelling capabilities. As a project we took on board these results and structured the review stage around the above themes and reconsidered our case studies in light of these reviews.

3 Review summaries

The aim of each of the following reviews was to look at the current state of the art and current practice in terms of modelling and compare to an idealised modelling framework thus identifying gaps or possible areas for model enhancements. This was possible for the first two themes where there is a history of model use for analysing demand restraint measures and public transport, however for land use measures and attitudinal measures a slightly different approach was adopted whereby evidence of impacts was sought from field trials. The following sections provide a summary of the reviews and key issues which arise. Section 5 then links the review material to the choice of modelling case studies. Each of the reviews is provided as an appendix.

3.1 Demand restraint modelling

The review concentrates on the modelling of road user charging schemes considering the following issues

- the conventional modelling methodology based on the four stage model
- the various road user charging schemes which require modelling
- the various responses to tolls that have surfaced in the literature
- recent examples of modelling from overseas and in the UK
- an improved modelling framework and implications of using the recently issued variable demand modelling advice(DfT, 2005).

From this analysis gaps in the modelling of schemes and responses to schemes are identified and areas for future research both within and outside DISTILLATE are put forward.

3.1.1 Conventional modelling methodology

In the last three decades or so, the basic form of the travel demand model that has predominated the literature and has usually been applied by practitioners is the "four stage travel demand model" as described in texts such as Ortuzar and Willumsen (1990). The following summarises the key characteristics of these models (Algers, 2000)

- built on a zonal basis but land use data is usually only input and usually separate from the main model.
- demand is on a per trip basis
- static structure (the demand and supply is related a one point in time)
- structured set of travel choices usually incorporating elements of the four stage models (i.e. trip generation, trip distribution, mode choice and route assignment)
- iteration to equilibrium
- treat user prices as an additional element of generalised cost (e.g. parking charges)

It is against this traditional form that the modelling issues are considered.

3.1.2 Types of road charging schemes

The types of scheme which were considered within the review and which require different modelling needs were :-

- point
- cordon
- area
- distance
- and congestion based charges.

In addition the charges imposed within these schemes may vary by time of day and vehicle type (e.g. motorcycles are exempt) and can vary by other factors such as vehicle occupancy (e.g. car-poolers are allowed to travel free).

3.1.3 User Responses

In general the literature has documented the following as responses to road user charging (Stopher (1993); SACTRA (1994); ROCOL (2000); Paulley (2000, 2003); Mattson (2004); Toner and Mackie(2005); Bonsall et al (2005))

1. Route diversion
2. Reducing the frequency of trips

3. Mode switching
4. Change destinations (in short run, this is practicable for only trips that are of a discretionary nature such as shopping rather than the commute trip)
5. Retime trip
6. Not make the trip
7. Consolidate trips (trip becomes part of a trip chain)
8. Change vehicle occupancy

There are also “second round” responses reported in the literature such as:

- Vehicle sale (changes in vehicle ownership)
- Long term destination changes (i.e. change employment/work from home) as opposed to the short run changes identified above.
- Land use changes

An interesting second order effect has been presented by Toner and Mackie (2005). They give an example of the introduction of an area charge scheme within the city centre. The first round effects might see vehicles divert to routes around the cordon which would increase congestion on the periphery. This in turn would make destinations outside the city centre less attractive; public transport might become more crowded, making them less attractive for trips to the city centre. Thus there are second round responses that need to be modelled as well.

Furthermore, there is evidence that the response itself is dependent on the charge and the response mechanism seems to be that at low charge levels, rerouting and retiming are more pronounced; at higher charge levels significant mode shift may occur (depending on modal alternatives), together with some destination switching. This evidence is based on work carried out for the Scottish Executive (2003).

3.1.4 Examples from current practice

The review details experience from modelling of road pricing schemes in Oslo, Copenhagen, The Netherlands, Hong Kong and Singapore as well as recent experience in the UK. It is evident from these reviews that not all of the above responses can be captured within the framework of the conventional travel demand model. In particular trip chaining and vehicle occupancy changes are some of the responses that cannot be captured within current frameworks as shown in table 2 which details the responses modelled by the recent work on the Road Pricing Feasibility Study (DfT 2004).

Table 2: Responses Modelled Within The Road Pricing Feasibility Study

STUDY	South and West Yorkshire Multimodal Study (SWYMMS)				London Orbital Model ("ORBIT")		Cambridge to Huntingdon Multimodal Study
Model Variant	SWYSM (Strategic Model)	Land Use Transport Interaction with Strategic Model	Detailed Transport Model	Detailed Transport Model with SATEASY	NAOMI	LASER	(no variant)
Route diversion	✓	✓	✓	✓	✓	✓	✓
Reduction in Frequency of trips	✓	✓	✓	P	P	✓	×
Mode switch	✓	✓	✓	P	P	✓	✓
Change destinations	✓	✓	✓	P	P	✓	✓
Trip Retiming[2]	✓	✓	✓	P	P	×	×
Trip chaining	×	×	×	×	×	×	×
Changes in Vehicle Occupancy	×	×	×	×	×	×	×
Vehicle sale	×	×	×	×	×	×	×
Land use changes	×	✓	×	×	×	✓	✓

Key: ✓ Response can be modelled
× Response cannot be modelled
P Response can only be partially modelled or subsumed

Some interesting comments can be made regarding the models within the RPFS.

- Trip chaining cannot be modelled; this is a recognised weakness of conventional modelling (Kitamura et al,1996)
- Trip retiming response is at the broad macro level and not at the micro level where changes of 5-10 minutes in departure time are modelled.
- Changes in vehicle occupancy were not modelled
- Changes in vehicle ownership were not modelled

For models utilising SATEASY (Hall et al, 1992), the "elastic assignment" is assumed to encompass a wide range of the responses subsumed within the elasticity of demand with respect to cost factor; it is recognised that this elasticity method is not sufficient (Oladeinde(2005), DfT(2005)). Until recently, practitioners carrying out variable trip matrix assignment assumed that trips between an Origin Destination (OD) pair were simply a function of cost of travel between that OD pair **ONLY** and this ultimately is influenced by the elasticity of demand, often input as an exogenous parameter. A single exogenous elasticity parameter cannot capture the whole range of responses or changes to the travel choice set because elasticities themselves are not constant and would change when the travel choice set changes.

[2] Only Time of Day (i.e. Macro time period choice not micro level)

When linked to the more strategic models, most allowed for feedback in the response (i.e. cost information from the assignments was fed back into mode choice, trip distribution and trip generation). It was found that rerouting was the most common response but that changes in trip frequency/generation were least likely. The rerouting phenomenon was observed less when distance charges were flat (equal across all links) compared to when charges were applied following the DfT's more complex specifications for distance based charges.

It has been recognised in the modelling work that "there is little experience of using such models for this (road pricing) purpose and even fewer examples of pricing in practice against which such models can be validated" (MVA, 2004).

Originally, the DfT wanted the consultants to explore area charges but it was suggested that the consultants lacked the expertise to model area charges (KBR, 2004) within the timescale of the RPFS. This issue is raised as a possible area for further research within DISTILLATE.

3.1.5 The variable demand modelling advice VADMA

The review then looks at an improved modelling framework and considers the recent advice on variable demand modelling VADMA.

The DfT has recently issued draft guidance[3] on Variable Demand Modelling. (VaDMA). The aim of VaDMA is to ensure that scheme appraisal considers "extra trip making, redistributed trips, modal transfer" (Oladeinde, 2005). This is a recommended way forward in modelling as perceived by the DfT. This framework can be applied within the context of modelling road user charging.

VaDMA in its simplest form is an implementation of the four stage model that utilises the logit form for the specification of a choice hierarchy that allows interaction through the various stages of the conventional four-stage transport model. VaDMA in essence pictures trip generation, trip distribution and mode choice as representing the "Demand" side of the transportation system and these outputs (matrices) are subsequently assigned (i.e interacted with the supply represented by the network) and costs obtained are fed back to the Demand system through cyclic iteration so that some equilibrium is reached.

In addition, VaDMA gives clear guidance on the segmentation of demand (in TAG Unit 3.10.2). These guidelines are the minimum and they do not imply that adhering to this minimum would always be adequate. The minimum segmentation is given in TAG Unit 3.10.2 (page 13) as follows:

- Household type and traveller attribute (segmentation into car-available/no-car available or by household car ownership of 0, 1 or 2+ cars)
- Value of Time accommodated by the trip purpose split; In addition explicit advice is provided for schemes specifically involving charging in that there

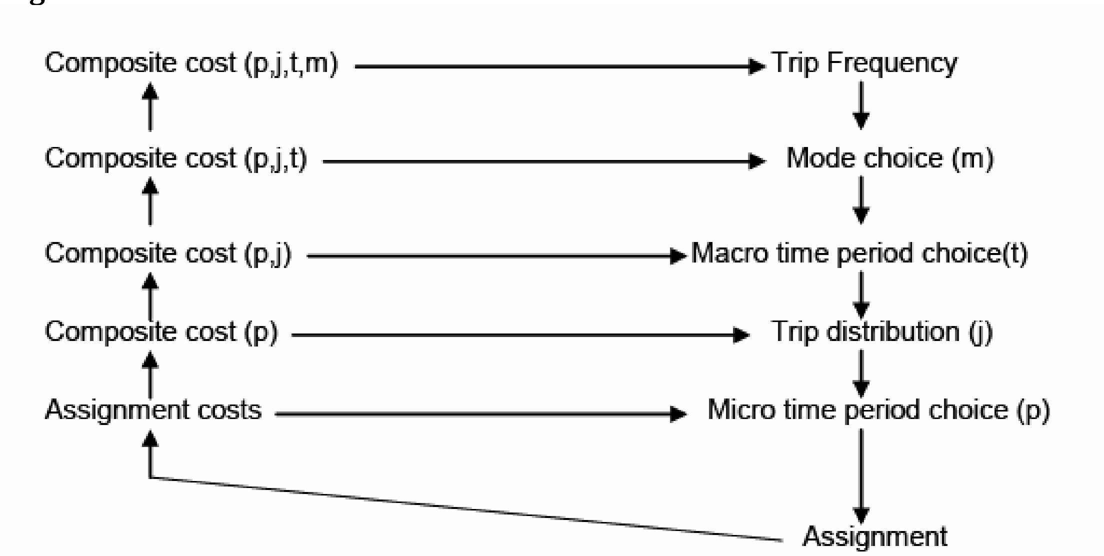
[3] Draft guidance was released in September 2005 with a consultation period of 3 months but thus far the guidance has not been formalised (see http://www.webtag.org.uk for further information.)

should be some segmentation by willingness to pay or income and trip distance. The latter is particularly important if there is a large range of trip distance.

- Trip Purpose: Segmentation into Work/Employer's Business/Other
- Mode: Car/ Public Transport
- Road vehicle types: Car and Other (e.g. Freight).

VaDMA provides a "sample" VADMA model structure which is a variant of the conventional four stage model (see Figure 3). This sample does not mean that it is the recommended model but rather based on the available empirical evidence collected thus far (Bly et al, 2001), this would be the most appropriate form for a variable demand model. This would be valid for Highways' Agency type schemes that are essentially interurban. But this model structure may not be suitable in application to urban schemes such as those involving the introduction of road pricing in city centres of the UK.

Figure 3 SAMPLE VADMA MODEL



(Source: From TAG UNIT 3.10.3 page 22 copyright DfT,2005)

Some elements stand out in this model structure:

- As this model is based on hierarchical multinomial logit, to provide sensible responses, the least sensitive elements appear at the top (i.e. trip frequency) while the most sensitive elements are at the bottom (i.e. assignment). Hence it is interesting to note that in this default model structure, trip distribution is more sensitive than mode choice. This is a result of the evidence gathered through a review of a number of UK and overseas models presented in Bly et al (2001).

- One of the new elements central to the VADMA approach introduced is "time period choice". This is subdivided into macro and micro time choices. Macro time period choice, involving the transfer of trips between broad time periods, can be modelled as a logit choice in a similar way to the choice mechanisms described for the other stages of demand modelling and that these should be considered when strong cost differentials between time periods are expected to develop or change. Hence this is particularly important for differential pricing schemes where different charges apply say, during the AM peak and the Interpeak. VADMA also emphasises micro time period choice, more commonly referred to as "peak spreading". Evidence exists to show that travellers can alter their departure times and the probability of peak spreading increases with worsening congestion (the peaks become longer).

- Trip generation stage is almost taken as synonymous to trip frequency stage but trip frequency embodies the response of the trips to changes in travel cost.

In practice, little has been reported utilising the VaDMA methodology for modelling of road pricing schemes given the date of release of the VaDMA guidance and hence there is little to comment here in this respect.

It is important to note that the micro time period choice model suggested to be incorporated within VaDMA has not yet been fully developed. The software for this ("HADES") (Van Vuren 2002) has been developed but is not on general release to practitioners at time of writing. Hence while the recommendations in VaDMA suggest that micro time period modelling be carried out as a matter of course the advice also recognises that "its modelling is complicated and uncertain". There is continuous research looking at the integration of the departure time choice models within VaDMA (Oladeinde, 2005). Finally there is little information at time of writing about the convergence requirements to be adhered to when using Variable Demand Models for forecasting, although we understand that its release would be imminent.

3.1.6 Gaps in modelling schemes and responses

The review concludes by identifying gaps in the modelling of schemes and responses and suggesting a way forward in terms of research areas. The following summarises the gaps while the way forward within DISTILLATE case studies is discussed in section 5. In addition to the review of road user charging some of the local authorities identified a problem with the current modelling of parking (capacity and choice) and workplace parking levies. These are taken into account below under D12-13.

The gaps in modelling were set out as follows :-

D1. **Area based charging schemes**

Modelling response per day or tour rather than per trip is the issue here. Whilst some models can deal with tours most assignment models do not.

D2. Modelling of exemptions or discounts

Exemptions for residents – the problem here is matching data to trips in the assignment. Exemptions by vehicle type or occupancy level are normally dealt with by applying factors outside the modelling of responses.

D3. **Staggered charge regimes**

Modelling departure time responses to charges which vary within the peak requires micro time shifts and is limited by the length of time period modelled for static models.

D4. **Representation of delay**
As flows approach capacity representation of delay is critical to determining the route choice and in setting the optimal toll levels. Current speed-flow relationships are sometimes simplified around capacity to improve the assignment process or to ensure a system optimum can be calculated.

D5. **Modelling monthly tickets/passes**
If users can purchase a monthly ticket then this affects their behaviour throughout the four stage process- from frequency of trips to route choice.

D6. **Micro level departure time choice**
This is linked to D3 above but could also be an important response to avoid peak of peak congestion under any scheme.

D7. **Trip chaining**
Although some models use tours rather than trips there are few examples around the World which really address the issue of trip chaining as a response mechanism where trip purposes are “chained” together. (Note VISSUM is able to represent trip chaining).

D8. **Changes in vehicle occupancy**
Few models attempt to predict the transfer from car passenger to drive or vice versa. The problem lies with evidence on response rather than model structure.

D9. **Vehicle availability and ownership**
As charging is introduced there will be an impact on availability of the car within households. At present the joint decisions of households on car use is not modelled. It is also desirable for the increased running costs of car use to feed through to the long term decisions on car ownership.

D10. **Park and ride response**
The review identified some criticism about the attempts at or simple lack of modelling of park and ride responses. (Usually aimed at assignment models)

D11. **Land use responses**
While there are land-use models available such as DELTA, MEPLAN and MENTOR, such models are expensive to set up and operate and thus only larger authorities are likely to possess this form of modelling capability. Whether such models are required for smaller authorities is of interest.

D12. **Car park capacity and choice**
Modelling car park capacity and impact on car park choice was identified as a gap by local authorities in the initial survey.

D13. **Workplace parking levy**
Modelling of workplace parking levies could be improved.

D14. **Scheme design**
Finally although not a modelling gap, there is a gap in methods for scheme design.

3.2 Public transport modelling

This report reviews a wide range of public transport models covering a number of modes and purposes. In order to facilitate comparison the models are split into the following categories:

1) Rail models
2) Bus models
3) Multi-modal & Network based models

Within each category there are a wide range of demand based models ranging from simple static elasticity models to more complex dynamic, network based models which consider both supply and demand. The review compares the modelling approaches and identifies gaps or weaknesses within each approach by looking at how each model deals with a range of instruments split into "hard" and "soft" instruments.

The term 'hard instruments' relates to variables which are easily quantifiable and for which well established relations with demand are known. Public transport fare and service elasticities have been well researched and a series of empirical studies, based on both revealed and stated preference studies, has established accepted values. Similar research has been carried out for the main alternative, private car vehicles and also for cross demand effects between the two (TRL, 2004). Less is known about 'soft instruments' which are much harder to measure and whose value remains subjective to the traveller. Measuring the value placed upon 'personal security' or 'cleanliness' has relied on the use of stated preference techniques and the values are less well accepted in comparison to 'hard values'. These values are however being seen as increasingly important by transport practitioners as they try to complete the picture on how travellers react to non-conventional public transport, i.e. rapid bus transport, park and ride, new information services etc.

Both 'hard' and 'soft' instruments tend to be viewed as short term measures since they can be implemented with very short notice, although some instruments such as a new stations take several years to come on line their impact is felt immediately. The opposite applies to socio-economic, lifestyle and land use impacts which tend to be classified as medium to long term instruments/influences. For example, the performance of the economy can impact upon public transport demand via employment and disposable income levels; larger numbers of single person households may increase car ownership and lead to reductions in public transport demand; a move towards sustainable living may increase public transport demand; whilst a desire to save time by trip chaining may replace journeys previously undertaken by public transport with private car trips.

The following sections summarise the nature of the models and identify the gaps for each type of model.

3.2.1 Rail Models

As the heading implies these models are uni-modal in nature and aim to predict changes in rail demand via factors that are both endogenous and extraneous to the rail market. That is not to say they don't consider other modes, but when they do it is to assess how such competition affects the demand for rail and tends to be based on known diversion factors that can be implemented at a static rather than dynamic level.

There is a mixture of static and dynamic analysis with the latter linked to LUTI models such as EMME/2. The majority of the models tend to concentrate on 'hard' instruments/influences and some also look at socio-economic instruments/influences with lifestyle and land use instruments/influences conspicuous by their absence. The PDFH is able to assess the impact on demand of a wide range of hard, soft and socio-economic factors, however each is in isolation of one another. The level of aggregation can vary between models as can the time scales. The variability in the latter will depend upon what policy or project is being assessed. If a train operator company wishes to know the impact of a change in the service frequency it offers it will only be interested in the short term implications of this. If on the other hand it is thinking about investing £0.5 billion in new rolling stock it will be interested in the medium to long term impact on rail demand. The suggested gaps in rail modelling were as follows :-

PT1. Improving Cross Modal Impacts - A number of the rail models make an attempt to take into account cross modal impact via static diversion factors and elasticities. This leads to static analysis and mis-estimation of impacts if the data or underlying assumptions about the relationships is inherently wrong. There is a need to introduce some dynamics into the cross modal relationships by testing out policies not related to rail but to other modes of transport, i.e. private car or bus.

PT2. Inclusion of Soft Variables - The majority of the models don't take into account 'soft' instruments such as rolling stock quality. There is a need to take into account their impact upon demand.

PT3. Introducing Social-Economic Impacts - In most of the models these impacts are provided as static exogenous factors. There is a need to make these endogenous to the model or link them to another model which can provide some dynamism to the analysis.

PT4. Introducing Lifestyle Influences - To date there has been no research that has examined the impacts on rail demand of lifestyle influences such as trip chaining, sustainable living etc.

PT5. Land Use Influences – There appears to be little consideration of land use influences.

3.2.2 Bus Models

As with the rail models, the bus models are uni-modal in nature and aim to predict changes to bus demand via endogenous and extraneous factors. The 'hard' and 'soft' factors tend to predominate with no coverage of issues such as lifestyle and land use instruments/influences. In recent years the 'soft' factors have received much more coverage and are increasingly seen as important elements in generating new demand and retaining existing demand. As with rail cross modal effects are considered in as much as how competition from other modes impacts upon bus demand and tends to take the form of modal diversion factors rather than dynamic interaction.

The level of aggregation can vary between models, whilst in every case the time scales of the models are short. This might reflect the short term nature of the bus business and the flexibility of bus assets. The key aim for any bus operator is to make a short term profit, whilst for central and local government it is to keep within this and possibly next year's budgetary constraints with regards support for bus services. As such most of the modelling work tends to be short term in its outlook. Even when a major national bus company is making major investments in rolling stock, the flexibility of bus vehicles means that the risk can be spread out across the companies many regions, i.e. if buses aren't required in Leeds then move them over to Leicester. The suggested gaps in bus modelling were as follows :-

PT6. Long Term Impacts – A need to consider demand impact over the longer terms including the inclusion of socio-economic, lifestyle and land use instruments/influences.
PT7. Bus Rapid Transit (BRT) – Examine the impacts of such schemes on bus demand.
PT8. Lifestyle Influences – What are the impacts of trip-chaining, sustainable living etc.
PT9. The lack of explicit treatment of capacity and the impact on users routing strategy.

3.2.3 Multi-Modal Models

As the title suggests these models examine more than one mode at the same time and perhaps more importantly cross modal effects on demand for each mode. This is not always as straightforward an example as say a cut in bus fares leading to a modal shift away from car. Higher car ownership may lead to a reduction in bus demand initially but then increased road congestion may see bus demand rise as travellers notice buses passing them in bus lanes. The interaction can be very complex especially for dynamic/quasi dynamic models that are based on a coded network carrying several modes to large numbers of O-D zones.

Road Traffic & Public Assignment Models

All these models are based upon coded networks which will vary in coverage and detail, dependent upon the resources available to the transport practitioner using them. There appears to be quite good coverage of 'hard' instruments/influences and because all modes are coded onto the same network the interaction between the modes tends to be dynamic in nature. EMME/2 and VISUM appear to be able to model park and ride and other inter-modal trips which also allows them to examine trip chaining and activity analysis. EMME/2 also takes into account overcrowding levels on public transport but its not clear if this is simply a constraint on demand that can be carried or an input into the cost function (via additional vehicles). Unlike the bus and rail models overcrowding does not appear to be factored into any generalised cost function as a dis-benefit to the traveller. The major gaps appear to be the absence of

'soft', socio-economic and land use instruments/influences. In terms of time scale it would appear that all the models are interested in the short term impacts.
The gaps were identified as follows :-

PT10. Improvement of demand models – By the inclusion of the impacts from 'soft' variables.
PT11. New PT Modes – Examine impact of quality bus routes and BRT.
PT12. Lifestyle Influences – What are the impacts of trip-chaining, sustainable living etc.

Micro-Simulation Models

These models have been developed recently and can be seen as a branch of assignment models in that they offer a more detailed viewpoint of how traffic behaves on individual routes via real time (or semi-real time) visualisation of traffic moving along links in a network. They also offer more disaggregated outputs per link/junction that a typical assignment model. The type of assignment offered within the models can range from the very basic 'all or nothing' to the more advanced 'stochastic' and even 'dynamic' assignment which allows car drivers to alter their route during their journey in response to delay information. To date the role of public transport within these models has been limited but two models are in the process of addressing this. Both STEER and DRACULA are involved in ongoing development as part of the DISTILLATE (see description of case studies below).

The gaps which we intend to cover include :-

PT13. Improvement modelling of route choice of bus users
PT14. Explicit representation of the capacity of buses and the impact on route choice

Strategic Transport and Land-Use/Transport Interaction (LUTI) Models

All these models consider 'hard' instruments and the majority tend to consider socio-economic instruments/influences. Both the STM and the START/DELTA models appear able to model new public transport infrastructure such as park and ride. It appears that such new services are described in the same generalised cost terms as existing public transport services. As such they do not take into account some of the softer variables which are normally associated with them, i.e. low floor vehicles, the quality of the vehicles and ride. The overcrowding modelling that appears in the STM and START/DELTA acts as both a constraint on demand and a dis-benefit to those travellers who experience them. All the models are based upon cities/regions but will differ in terms of O-D zone detail with the TPM model based upon 3 zones whilst others range between 30 to 100+ O-D zones. In terms of time scale there is a tendency for these models to estimate long term effects, though the STM model appears to buck the trend and looks at short term impacts.

The gaps for these more strategic models were identified as :-

PT15. Improved Specification – of supply functions/parameters new public transport infrastructure and modes such as heavy rail, quality bus routes, park and ride and BRT.

PT16. Inclusion of demand in response to soft variables associated with Quality bus routes.
PT17. Lifestyle Influences – What are the impacts of trip-chaining, sustainable living etc.

3.3 Land use measures

Two separate reviews were conducted under this heading. The first looked at the impact of controls on development densities and mix of developments, while the second looked at the encouraging public transport use through land use planning. By their very nature there is little modelling experience with these types of policies and so the reviews concentrated on definitions and evidence from theory and real life case studies. Thus the following sections only touch on the issues rather than identifying gaps in current modelling techniques (and no gaps are identified for case studies here).

In addition land-use models are complex and expensive to run and the economic assumptions underlying them are subject to more uncertainty and debate than in the case of transport models. At their best, they also seek to represent the temporal evolution of development taking into account the time-lagged behaviour of players such as developers and consumers in the context of the planning system. There is some value in sometimes adopting another approach and developing less complex models which simply look at the costs and benefits of given development patterns and seeking optimum situations on the basis of those costs and benefits. This is the aim of the STM Chelmsford study (see section 5.5 below).

3.3.1 Land use development densities and mix

Encouraging less motorised personal travel through land use involves the planning of new land use development and the management of existing land use in such a way as to bring origins and destinations closer together in order to help reduce private transport trips. This is normally done by increasing development densities or by organising the mix of land use types, or both.

Land use patterns affect travel behaviour. A variety of land use factors affect travel patterns including density, land use mix, roadway connectivity and design, parking facility design, and building design. Certain types of land use patterns are accessible by multiple modes, which reduces per capita car use, while others are car- orientated, which increases private car use.

How can land use density and mix encourage less personal motorised travel? (based on VTPI, 2001).

Density refers to the number of people or jobs in a given area. Mix refers to how land uses are arranged in relation to each other. If common destinations are located close together, this type of mix is sometimes known as 'clustering'.

Density and mix can have significant impacts on travel demand and travel patterns through the following mechanisms:

- Accessibility: The number of potential destinations located within a geographical area tends to increase with population and employment density, reducing travel distances and the need for private travel. For example, in low-density areas a school may serve hundreds of square miles, requiring most students to travel by motor vehicle. In higher density areas, schools may serve just a few square miles, reducing average travel distances and allowing more students to walk or cycle. Similarly, average travel distances for errands, commuting and business-to-business transactions can decline with density.

- Transport choice: Increased density tends to increase the number of transport options available in an area due to economies of scale. Higher density areas tend to have better pedestrian and bicycle facilities and better public transport service because increased demand makes them more cost-effective.

As a result of these factors, higher density and clustered land use mix together tend to reduce per capita car ownership and use, and increased use of alternative modes (Jack Faucett Associates and Sierra Research, 1999 in VTPI, 2001).

International studies indicate that increased urban density significantly reduces per capita vehicle travel, as illustrated in the figure below (Kenworthy and Laube, 1999 in VTPI, 2001). This occurs in both higher-income and lower-income regions.

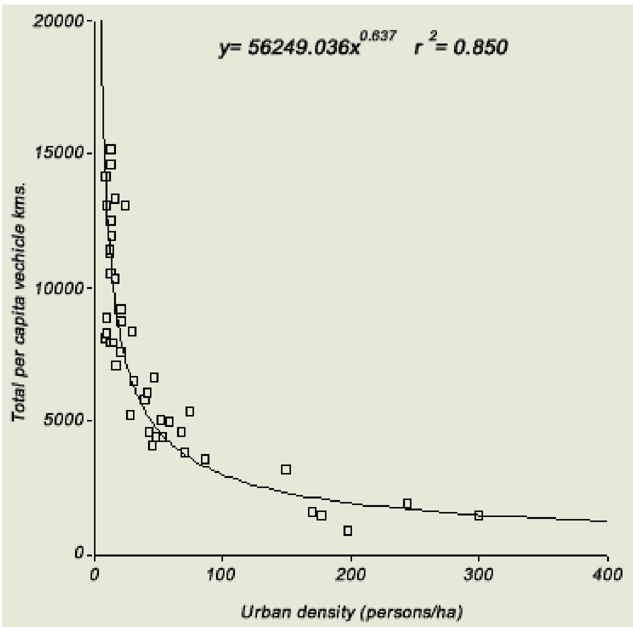


Figure 4 : Urban Density and Motor Vehicle Travel (Kenworthy and Laube, 1999)

Each point marked on the graph represents a major international city. Per capita vehicle use tends to decrease with density.

It has also been found that average vehicle ownership, vehicle travel, and vehicle expenditure per household decline with increasing residential densities and proximity to public transport, holding constant other demographic factors such as household size and income. The importance of the interactions between spatial (land use) planning and management, and the design, operation and use of transport systems, is fully recognised. Important aspects of this are (Cost Transport, 1998):

- the spatial organisation engendered by the evolution of the production process increases personal mobility requirements (and those for goods movements),
- low density development, particularly in the suburbs, has encouraged the growth of travel and of multi-car households;
- the growing polarisation of commercial structures has also led to an increase in personal travel, particularly by car.

The reversal or reduction of these land use development trends will tend to reduce the need to travel in general and travel by car in particular. Land use changes, however, take quite a long time, so this is not a short-term policy instrument.

The trends listed above may be illustrated by the cases shown in the following table:

Relationship between transport and location of property development	
Location/land use	**Effect**
Out-of-town business parks, UK	93% use car to travel to work
Gateshead MetroCentre, UK	80% travel by car compared to 27% to the city centre
Copenhagen insurance company moving from centre (near station) to suburbs	Car commuting up from 26% to 54%
Supermarket on free-standing outer London site	95% by car compared to 33% for inner London supermarket

Table 3: Relationship between transport and location of property development (Source: Lucas, Marsh and Jones, 2000, p.16).

The table below indicates how various land use design features are estimated to reduce per capita vehicle trip generation compared with conventional development that lacks these features (VTPI, 2001).

Design Feature	**Reduced Vehicle Travel**
Residential development around public transport nodes	10%
Commercial development around public transport nodes	15%
Residential development along public transport corridor.	5%
Commercial development along public transport corridor.	7%
Residential mixed-use development around public transport nodes	15%
Commercial mixed-use development around public transport nodes	20%
Residential mixed-use development along public transport corridors.	7%
Commercial mixed-use development along public transport corridors.	10%
Residential mixed-use development.	5%
Commercial mixed-use development.	7%

Table 4: Travel Impacts of Land Use Design Features (Source: VTPI, 2001)

Of all the instruments of transport policy, land use instruments are perhaps the ones which, potentially at least, can have the greatest impact on reducing the amount of motorised travel. However, they are also the ones which take the longest to implement and thus to bear fruit. The greatest opportunities for change are in the circumstances of entirely new development, when land use densities and mixes may be specified in advance. Even in these conditions however, results will take years to materialise.

The amount of reduction in motorised travel in response to land use instruments, will depend on:

- the scale of the land use changes;
- the design and type of the changes, in terms of density and mix;
- the speed with which the changes are effected.

In all cases, there will be no response in the short term and very little in the medium term. Though there are many case studies of schemes intended to reduce travel by land use planning there are few, if any, case studies which have quantified the real travel-reduction effect. The main reason for this is the difficulty of comparing before and after conditions for an instrument that takes so long to implement and for effects to be felt.

One study of travel patterns in a North American suburb found the elasticity of transit (public transport) mode split with respect to land use density to be +0.10 to +0.51, depending on type of land use. This means that each 1.0% increase in density increases public transport use by 0.1-0.51% (Cervero, 2002 in VTPI, 2001). The same study calculated the elasticity of per capita vehicle trips and vehicle travel with respect to various land use factors, as summarised in the table below. For example, this indicates that doubling neighbourhood density reduces per capita car travel by 5%. Similarly, doubling land use mix or improving land use design to support alternative modes also reduces per capita car travel by 5%. Although these factors may be small, they are cumulative. (VTPI, 2001)

Factor	**Description**	**Trips**	**VMT**
Local Density	Residents and employees divided by land area.	-0.05	-0.05
Local Diversity (Mix)	Jobs/residential population	-0.03	-0.05
Local Design	Sidewalk completeness/route directness and street network density.	-0.05	-0.03
Regional Accessibility	Distance to other activity centres in the region.	--	-0.20

Note: Trips = vehicle trips; VMT = vehicle miles travelled.

Table 5 : Typical Elasticities of Travel With Respect to the Built Environment (Source: VTPI, 2001)

This suggests that neighbourhood design factors (density, mix and design) can reduce per capita vehicle travel on the order of 10-20%, while regional accessibility factors (i.e., where a neighbourhood is located with respect to the urban centre) can reduce car travel by 20-40%.

Obviously further research is required to provide evidence on such elasticities in the UK context. What can be done with current models is to test the impact of mixed use developments and greater densities in urban areas at the generation stage feeding through the development controls to the “production” and “attraction” matrices. This will then feed through to mode choice and should result in shorter average trip lengths.

3.3.2 Encouraging public transport through land use planning

Encouraging public transport use through land use planning involves the planning of new land development and the management of existing land in such a way as to:

- improve conditions for the efficient operation of public transport,
- locate land uses close to public transport services which serve them, and
- increase the demand for public transport, particularly by encouraging mode change from the private car.

Several studies indicate that if development is planned specifically to encourage public transport there can be a significant reduction in per capita car travel. Public transport nodes, including rail stations, serve as a catalyst for more accessible land use by creating higher density, mixed-use, pedestrian-orientated centres. Households living in such neighbourhoods tend to own fewer cars, and people working in such areas are more likely to commute by alternative modes (partly because they do not need a car for lunchtime errands).

These factors result in higher levels of public transport commuting, increase nonmotorised travel for non-commuting trips (such as shopping and trips to school), and reduce car travel. As a result of these various factors, there tends to be a "leverage" to much greater reductions in vehicle travel than that which is directly shifted from car to public transport. It has been estimated that each passenger-kilometre of rail travel appears to be associated with a reduction of 5 to 7 kilometres of car travel through these various mechanisms.

A number of studies have concluded that public transport service can facilitate land use development patterns, but is only one of many factors, and will not cause significant land use or travel behaviour change by itself. If an area is ready for development, improved transit service (such as a rail station) can provide a catalyst for higher density development and increased property values, but it will not by itself stop urban decline or change the character of a neighbourhood. (Material in this and the previous two paragraphs is from studies by Cambridge Systematics (1994), Newman and Kenworthy (1998) and Badoe and Miller (2000), all as summarised by VTPI, 2002).

In practical terms, this means that there are two specific but inter-related ways in which land use planning can encourage the use of public transport:

- by locating trip origins and destinations near public transport routes;
- by ensuring trip densities are sufficiently intense to establish an efficient service.

The general principle is thus to ensure that trip origins and destinations are arranged in nodal or linear patterns which are compatible with the demand patterns needed to ensure that public transport services, both bus and rail, are viable and efficient.

It is important to note that the effects of land use planning on public transport use are likely to be greatest where sufficiently strong regulation of land use is in place.

In its guide 'Shaping Up', the state government of Queensland (Government of Queensland, undated) offers guidance on the design of public-transport-friendly development, in the form of idealised 'how to do it' and 'how not to do it' examples.

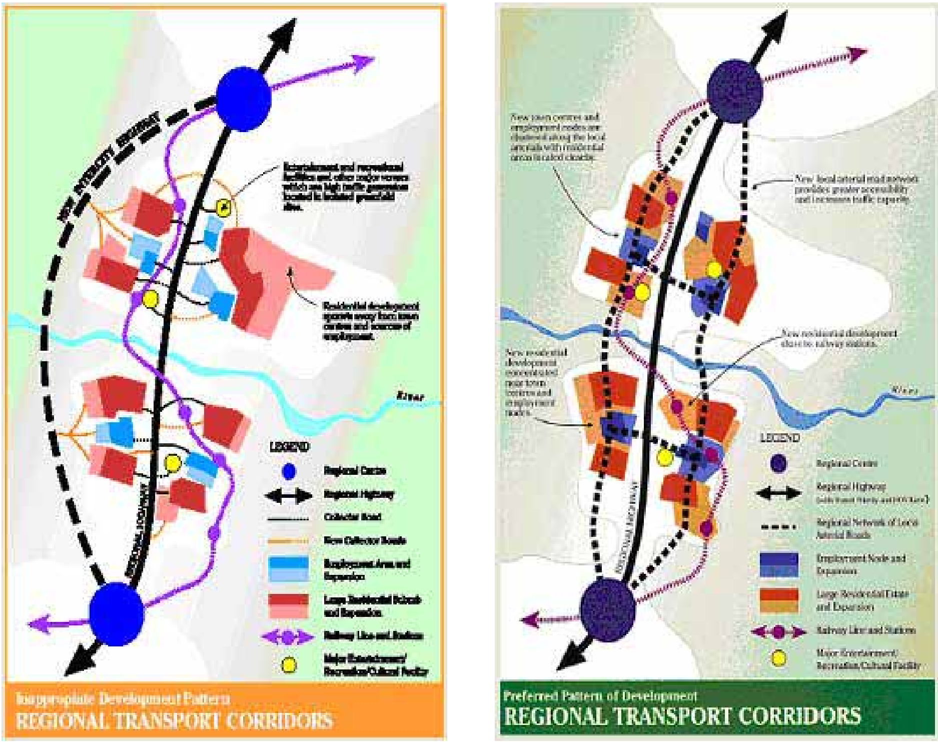


Figure 4: an example from ‘Shaping Up’ (‘preferred’ plan on right)

The Guide describes the principles involved in the design of transport corridors for improved public transport as follows:

> "Urban growth often takes place along corridors created by major highways or railway lines. The way in which these transport corridors are planned and designed at the regional level can have major implications for public transport use. Corridor planning and the distribution of land uses also impacts significantly on public transport costs, operational efficiency and funding requirements".

The Guide suggests the following approaches to good practice:

- Public transport is more cost effective and efficient if organized along a linear corridor with highly accessible activity nodes, so development should be concentrated along major corridors based on a main 'line haul' public transport route (with feeder routes wherever appropriate).
- Major activities, employment nodes and higher density residential areas should be encouraged near stations, significant stops and interchanges along public transport routes (preferably within 800 metres of a railway station).

- Urban development should be compact, concentrated along public transport corridors, and focused around key business and activity nodes which incorporate public transport interchanges.
- The overall road network should ensure that 90 per cent of the urban area is within 400 metres of public transport stops located on the arterial and collector road network. (This also supports faster public transport services and enables stops to be 250 metres apart).
- A mix of business and residential land uses should be concentrated at clearly defined nodes located at the intersection of local arterials where 'line haul' public transport services converge. This concentrates trips at a discrete number of locations which allows multi-purpose trips and increases public transport passenger loadings.
- Public transport interchanges should be integrated into these mixed-use business and activity nodes. This increases public transport use and enables easy and convenient passenger transfers between bus, rail and taxi services." ('Shaping Up': Government of Queensland)

It should be noted that large scale park and ride facilities can conflict with accessibility and liveability benefits: a railway station that is surrounded by large parking areas and by main roads with heavy traffic is unlikely to provide the best environment for residential development or for pedestrian access. As part of land use planning, it is thus important that such facilities be properly located, designed and managed to minimise such conflicts.

As with development densities and mix there is little before and after evidence and we rely on the same study as in section 3.3.1. For a North American suburb it was found that the elasticity of transit (public transport) mode split with respect to land use density was +0.10 to +0.51, depending on type of land use. This means that each 1.0% increase in density increases public transport use by 0.1-0.51% (VTPI, 2001). Again further research is needed to put this into the UK context and very little other than conventional modelling with sensitivity tests on assumptions regarding mode specific constants to represent increased use of public transport can be done at present.

3.4 Soft/Attitudinal measures

Two reviews were carried out under this heading, one on the impact of flexible working hours, the other on the impact of individualised marketing. The first of these on flexible working hours provided only limited evidence which appeared dated and as such it is not included in this document and the issues are not covered by any of the following case studies. However, it should be noted that the flexible working hours material is currently being updated. It is also worth noting here that attitudinal and behavioural measures, which are often referred to as soft measures, are now generally termed “Smart Choices.”

3.4.1 Individualised marketing/travel awareness campaigns

Individualised marketing campaigns to reduce car use are an interactive form of targeted ‘travel awareness’ campaign. Travel awareness campaigns are programmes designed to increase individuals' awareness of alternatives to car use. Campaigns can range from blanket advertising, through publicity stunts to individualised marketing projects, now more commonly referred to as personalised journey planning in the transport sector. It is also possible to run both types simultaneously, such that the advertising supports the individualised marketing.

There are a number of stages in the process of changing behaviour as identified by Prochaska and DiClemente in the Transtheoretical Model (Prochaska and DiClemente, 1983 and 1992; Sutton, 2001) on the way to achieving a reduction in car use, through information and persuasion. These stages are equally applicable to changing travel behaviour, and have been adapted into a seven stage model for the transport sector through the TAPESTRY project (TAPESTRY, 2003), as follows:

1. Awareness of problem,
2. Accepting responsibility,
3. Perception of options,
4. Evaluation of options,
5. Making a choice,
6. Experimental behaviour,
7. Habitual behaviour.

It should also be noted that having taken on board the need to change and/or actually made a change, drivers attempting to reduce their car use can relapse into old ways of thinking and behaving. Relapse may occur if individuals do not feel supported, they feel they are making changes in isolation, they feel they no longer ‘fit in’, the alternatives they are using do not adequately meet their needs or involve too much effort, or they perceive that the need to use cars less has receded. Such relapses may not be permanent. Individuals can cycle backwards and forwards through the stages of change several times according to Sutton (2001). Often the change will be longer lasting each time until it becomes habitual.

The first five stages are unlikely to result in substantial change in levels of car use, although a few innovative and/or already environmentally conscious individuals may move through the first five stages almost simultaneously, such that they appear to move straight from awareness to behaviour change. These first five stages can be influenced by more general awareness campaigns, but to achieve more substantial change, more interactive and targeted marketing is needed to support those with little positive concept of using alternatives to the car make changes in their travel habits. The most effective way of doing this is to identify individuals who are willing to consider changing their travel habits, find out what journeys they make and provide information and support regarding specific alternatives available for those journeys. This process is known as individualised marketing to reduce car use. Such individualised marketing can also be used to support and promote other measures that provide alternatives to solo driving, e.g., the introduction of a guided bus.

Individualised marketing campaigns to reduce car use can be the sole constituent of a ‘travel awareness’ campaign and many are designed to incorporate information to raise awareness in their early stages. Individualised campaigns are now run by a number of consultants, with Travel Blending® run by Steer Davies Gleave, and IndiMark®/Travel Smart® operated by SocialData. These campaigns are adapted for each new situation, with some notable product evolutions. Travel Blending® now forms part of Steer Davies Gleave's Living Neighbourhoods® programme, which incorporates a variety of community initiatives. Travel Smart® run by Western Australia Metropolitan Transport Department has evolved into an umbrella brand for a series of educational programmes in schools and work with employers and community groups to reclaim streets and improve the environment. Additionally, Travel Smart in Western Australia has links into national programmes such as the Smogbusters environmental campaign. Similarly in the UK the term Travel Wise® is an umbrella brand for work to reduce car use. Hence, a Travel Wise® campaign could include an individualised marketing project, advertising of the negative impacts of car use and cycling promotion, for example.

Individualised marketing campaigns have a number of key stages common to most programmes, including:

- Recruitment of participants (usually by telephone, through the workplace or community),
- Collection of information about current journeys (again by telephone or through travel diaries),
- Provision of information on alternatives to solo car driving for particular journeys, and potentially other supporting actions, e.g., the supply of free trial bus tickets,
- A period of time for participants to attempt to reduce their car use,
- After data collection (by telephone or travel diary) for monitoring purposes, and to facilitate the provision of feedback,
- Feedback on the success of participants, and the difference they are making.

3.4.1.1 Evidence on performance

Results for a number of personalised journey planning applications are summarised here, including applications of Travel Blending®, IndiMark®/Travel Smart®, and other one off personalised journey planning projects. Results come from the Australia, Europe and the US. Results are summarised from Jopson (2006).

Travel Blending®

Travel Blending® works with individuals and households. Most often, individuals are recruited through the workplace, and the individual then co-opts the rest of their household, but recruitment through community networks is increasing. Travel Blending® is delivered through four "kits" and is described in some detail elsewhere, most recently in Rose and Ampt (2001) and Taylor and Ampt (2003). Kit 1 delivers introductory materials and the first of two travel diaries; Kit 2 provides feedback and suggestions as to how the household and individuals could reduce their car use – feedback and suggestions are based on the first travel diary, which has been analysed by an "expert system"; Kit 3 supplies the second travel diary; Kit 4 provides feedback on changes the household and individuals have been able to make, and further suggestions for continued change based on analysis of the second diary and comparison with the first (Taylor and Ampt, 2003). Each member of the household completes their own travel diaries; the first allows:

- the amount of travel to be quantified,
- the pollution generated to be calculated,
- consideration of household interactions which result in travel,
- generation of targeted suggestions about how to reduce car use.

The second diary:

- identifies change in travel behaviour,
- facilitates feedback to participants,
- monitors the impact of Travel Blending®.

Travel diaries record "all travel outside the home with details obtained of destination, place and purpose, start and end time of each trip, travel mode and for car driver trips, the odometer reading at the start and end of the trip" (Rose and Ampt, 2001). The diaries cover seven days as week day and weekend journeys can be very different; people may be more able to travel blend at the weekend than during the week, or vice versa. It was found that people did complete the full seven day diaries; possibly because they included a built in reminder system (Rose and Ampt, 2001).

Results from Travel Blending® applications in Australia, Europe, and the US are presented in Table 6, which is taken from Jopson (2006). The results presented here are for travel behaviour change amongst Travel Blending® participants – that is to say, no adjustment is made for non-respondents to give a figure for change across the wider population. Unadjusted figures are presented since these are more directly comparable with results of other personalised journey planning programmes, although adjusted results for Travel Blending® can be found in (Jopson, 2006). It is also worth noting here that in many pilot interventions the sample was recruited from local authority offices, and other organisations somehow involved in the project explicitly or more generally in work to reduce car use in the local area and region. Often, pilot projects are implemented with local authority and other staff potentially involved in a wider roll out of the project to provide a greater understanding of Travel Blending®, but it is argued here that staff with an interest may be more inclined to participate, note drop out part way through the intervention, and to actually reduce their car use, and thus bias the results. However, looking at the Australian examples in Table 6, the reductions in car use are very similar for both the Adelaide pilot, which is an employee based intervention, the others, which are with residents through Living Neighbourhoods projects. Comparing the three known pilot studies in Table 6 does not help either, since two with similar reductions in car use are in the UK, whilst the third in Australia has very different results, and it has been suggested that cultural differences (such as Australian's being more environmentally friendly, and being used to GPs providing Green Prescriptions which suggest changed behaviours relating to diet and exercise to cure minor ailments) result in greater reductions in car use in Australia (Buchanan), but there is no robust evidence for this. Sample sources for projects in Table 6 include:

- Adelaide pilot: staff from Transport SA (the South Australian department of transport), a private company, and a primary school - it is not clear whether the project extended to parents of the school children as it did in Leeds (DETR, 2001).

- Nottingham pilot: City Council staff – Travel Blending® formed part of the organisations travel plan activities (DETR, 2001).
- Leeds pilot: staff from METRO (the passenger transport authority), and the City Council Highways, Planning and Regeneration departments, parents of pupils at the Boys Grammar School, then located along a major radial public transport route in and out of the city centre, and a small number of staff from the Steer Davies Gleave offices (Steer Davies Gleave, 1998).
- Dulwich Living Neighbourhood: residents of the suburb - note Dulwich is a relatively wealthy suburb (DETR, 2001).
- Santiago: not known, but this is not a Living Neighbourhoods application, so it is assumed that participants are employees of an organisation, but it is not known whether they are employees of the local authority or private businesses.
- Christies Beach Living Neighbourhood: residents of the suburb – note Christies Beach is a relatively low income suburb (DETR, 2001).
- Holland Park Living Neighbourhood: residents of the suburb.
- New Jersey: employees of local businesses in the area, which is a “dormitory for New York City” (DETR, 2001).

A further issue to note in relation to Table 6 is that where only results from those who completed both travel diaries is reported, changes in mode choice appear artificially high. For example, in Nottingham there was a 3.3% reduction in car trips between diary 1 and diary 2 based on comparing all car trips reported in all diary 1’s returned with all car trips reported over all the second diaries. If the reduction in car use is calculated using participants who returned both diaries then the decrease is 7.6% (DETR, 2001).

In addition to considering changes in number of trips by each mode, it is also possible to compare total number of trips, and distance traveled before and after. DETR (2001) report the changes in distance traveled, and time in car as well as reduction in trips per mode. For those completing both diaries the number of car driver trips per driver fell by 7.6%, the number of car driver miles per driver fell by 14.2%, and the number of car driver hours per driver fell by 11.8%. Comparing all diary one returns with all diary two returns the figures are 3.3%, 6.2% and 4.8% respectively.

Table 6 Travel Blending® Results

		Percentage Change in Number of Trips by each Mode Amongst Participants							
Project	**Year**	**Car driver**	**Car passenger**	**Bus**	**Train**	**Walk**	**Bicycle**	**Sample (Households)**	**Notes & References**
Adelaide, Australia. Travel Blending® pilot study.	Base: June 1997							96	DETR (2001); Rose and Ampt (2001)
	After Intervention: cAugust 1997	-14.8%	8.2%					81	
	Later: November 1997							21	Further 5% reduction in car kilomtres
Nottingham, UK. Travel Blending® pilot Study.	Base: October 1997							85	DETR (2001); HUTT (2002)
	After Intervention: January 1998	-3.3%		+21%	+29%	+9%	-15%	36	
Leeds, UK. Travel Blending® pilot study.	Base: October 1997							152	Steer Davies Gleave (1998)
	After Intervention: March 1998	-5.6%	-10.6%	-4.7%	+5.7%	-3.4%	+10.2%	67	
Dulwich, Adelaide, Australia. Living Neighbourhoods®.	Base: 1998							201 (421 people)	DETR (2001)
	After Intervention: 1999	-10.2%	-9.4%	Public Transport +15.4%		+1.0%	-11.0%	201 (421)	Results from those completing both diaries
Santiago, Chile. Travel Blending®	Base: 1998							190	Hutt (2002)
	After Intervention: 1998	-25.4%							
Christies Beach, Adelaide, Australia. Living Neighbourhoods®.	Base: 1999							202 (348)	DETR (2001)
	After Intervention: 2000	-14.6%	-8.6%	Public Transport +22.9%		-2.0%	+20.9%	202 (348)	Results from those completing both diaries
Holland Park, Brisbane, Australia. Living Neighbourhoods®.	Base: 2000							115	DETR (2001)
	After Intervention: 2000	-9.3%	-0.1%	Public Transport +10%		+21.1%	+7.3%	?	
New Jersey, USA. Travel Blending®.	Base: 2000							131	DETR (2001)
	After Intervention: 2000	-14.3%	+9%			+11.5%		87	
Average % change between base and after intervention measurements		-13.2%	-0.8%	+8.5%	+17.4%	+6.2%	+2.3%		
				Public Transport +16.1%					

IndiMark® and Travel Smart®

The Travel Smart® individualised marketing was developed by Socialdata under the name Indimark® - the name by the project is known in much of Europe. Travel Smart® individualised marketing starts by identifying individuals who are prepared to think about reducing their car use through telephone surveys. Those completely resistant to the idea do not receive any further communication. Those who already use alternatives a lot receive some form of reward, which is found to increase use of said modes further. Those who are prepared to think about reducing their car use and participate in the project provide information about their journeys and receive targeted suggestions to reduce their car use. Suggestions are usually provided through a home visit (Brög and Schädler, 1999).

Like Travel Blending® the Travel Smart® product has evolved, and in Western Australian the Department of Transport (TransportWA) use Travel Smart® as a branding for a range travel behaviour change initiatives. Travel Smart® informs and motivates people to use alternative modes to the car, including ride sharing and telecommunications to reduce the need to travel for those who chose to do so. Like Travel Blending®, Travel Smart® does not set out to constrain mobility.

A pilot study was undertaken in South Perth in 1997, with approximately 400 randomly selected households. The pilot comprised a benchmark survey in August 1997, intervention in September/October 1997 and an evaluation survey in November 1997. A second and third evaluation survey were undertaken in September 1998 and February 2000 respectively. The percentage changes in mode choice resulting from the pilot study apparent at each stage of the evaluation are presented in the Table 7. Table 8 provides percentage reductions in the number of car trips achieved by a selection of IndiMark®/Travel Smart® projects. It worth noting here that IndiMark®/Travel Smart® has been implemented in some cities with the specific objective of increasing public transport patronage, where as elsewhere it is implemented to reduce car use per se. These later applications are more comparable with Travel Blending® which also seeks to reduce car use by which ever means is most appropriate, although IndiMark®/Travel Smart® does not tend to include encouragement of telecommunications to reduce the need to travel, trip chaining, undertaking multiple activities at one main destination, or using more local amenities as Travel Blending® does. With the exception of Goteborg and Viernheim, it is known that the applications reported by Richardson et al (2005) are all applications to reduce car use per se.

Whilst the projects reported by Richardson et al (2005) are in the main comparable with Travel Blending®, there are some differences. For example, the South Perth large scale application included, “the provision of about 175 bus stop specific timetable stands on the major bus routes in South Perth, and public awareness-raising in the local media and the community” (Socialdata, 2001). Thus, the large scale application in Perth included public transport system improvements, and a supporting awareness campaign, where as the pilot study did not. Whilst the combination of mutually supporting actions is explicit in this case, it is likely that few individualised marketing applications are in complete isolation, merely that actions are uncoordinated. For example, early applications of Travel Blending® were developed as part of the work to improve the environment in South Australia prior to the Sydney Olympics. It is also worth noting that Travel Smart® often includes the incentives to use public transport, including free trial passes known as test tickets for all participants, where as Travel Blending® may only provide such tickets for those who request them. In the Leeds Travel Blending® pilot programme such tickets were provided, but it is not clear whether they were provided in all case studies included in Table 6. Thus, it is apparent that there can be some variability between each individualised marketing campaign. This is in part because each campaign is rightly designed for local circumstances, but it does make objective comparison difficult. Evidence from the South Perth large scale application and elsewhere does indicate that individualised marketing can achieve greater results when explicitly combined with other actions to help reduce car use.

For the record, the fare box monitoring undertaken with the large scale Perth intervention revealed a 27% increase in bus patronage between the period March to June 1999 and the same period in 2000. Over the wider network, there was a 1.5% increase in patronage, thus the net increase resulting from the Travel Smart® individualised marketing is 25%.

Table 7 Travel Smart® Results for South Perth Pilot Project

	November 1997	September 1998	February 2000
Car as driver trips	-10%	-11%	-10%
Public transport trips	21%	No change	No change
Cycle trips	91%	No change	No change
Walking trips	16%	24%	16%
Car km travelled	-14%	-17%	-

Source: Department of Transport Western Australia (2000).

Table 8 Selected IndiMark®/Travel Smart® Results

IndiMark® Project	**Location**	**Scale**	**Relative reduction in car driver trips**
South Perth	Australia	Large Scale	14%
Goteburg	Sweden	Large Scale	13%
Viernheim	Germany	Large Scale	12%
Brisbane	Australia	Pilot	10%
South Perth	Australia	Pilot	10%
Gloucester	UK	Pilot	9%
Viernheim	Germany	Pilot	8%
Portland	USA	Pilot	8%
Cambridge	Australia	Large Scale	7%
Frome	UK	Pilot	6%

Source: Richardson et al (2005).

Following the Australian success, the 'Switching to Public Transport' demonstration project was initiated in Europe by the International Association of Public Transport (UITP). Indimark® was applied with the specific aim of increasing public transport patronage, and has since been adopted by a number of operators as part of their marketing strategy.

Like the results cited by Richardson et al (2005), those initiated by the UITP indicate that reductions in car use for projects seeking to increase public transport patronage are in the same range. It is also apparent where one year on data is collected that as for the Perth pilot intervention changes are sustained over two years, as can be seen in Tables 9a and b. Even where there is a slight reversal in changes in travel behaviour, there is still less car use and more public transport use two years on than before intervention. The interventions reported in the tables below are all standard IndiMark®/TravelSmart® applications, further results from non-standard applications are reported in Jopson (2006) – many results are in the same order of magnitude.

Table 9a IndiMark® Europe Mode Switch: percentage using each mode before, after and 1 year on

Mode	München			Bremen			Köln-Mülheim			Wiesbaden			Nürnberg			Kassel		
	B	A	1yr	B	A	1yr	B	A	1yr	B	A	1yr	B	A	1yr	B	A	1yr
Walk, bicycle	50	48	46	42	41	40	33	31	30	28	27	27	27	29	26	25	23	23
Motorised private transport*	22	19	18	31	30	30	36	34	35	43	41	41	44	38	40	48	44	46
Passenger	6	6	6	9	9	10	11	10	10	12	13	13	15	10	13	19	16	15
Public transport	22	27	30	18	20	20	20	25	25	17	19	19	14	23	21	8	17	16

Notes: *includes motorcycles and scooters. B – Before; A – After intervention; 1yr – 1 year after initial after survey
Source: Brög and Schädler, 1999.

Table 9b IndiMark® Europe Mode Switch: percentage using each mode before, after and 1 year on

Mode	Delft/ Den Haag			Montpellier		Bologna		Parma		Regigio Emilia		Torino		Venezia		Madrid		Porto	
	B	A	1yr	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A
Walk	19	17	17	15	17	8	7	5	5	6	9	14	12	7	9	-	-	9^	9
Bicycle	31	33	34	2	3	4	3	13	12	14	13	1	1	16	12	-	-		
Motor-cycle	0	0	0	0	0	9	6	9	8	5	4	1	1	2	2			2	1
Car as driver	32	34	31	65	63	46	43	53	44	50	51	45	35	32	28	79*	75	51	52
Car as passenger	14	12	12	10	9	7	5	7	7	7	5	7	4	4	3	12	11	16	15
Public Transport	3	3	6	5	5	25	34	12	24	14	17	32	47	36	45	7	13	22	22
Other	-	-	-	3	3	0	1	1	0	3	1	0	0	2	1	1	1	1	1

Note: 1 year on data only collected in Delft/Den Haag. – data not collected. *includes motor bikes. ^includes bicycle.
Source: UITP, 1998.

One further standard IndiMark®/Travel Smart® intervention in Lisboa reported by UITP (1998) includes a control group. The results are reported in Table 9c, and indicate that the intervention has reversed the trend for increasing car use in Lisboa. However, it is worth bearing in mind that the control group appear to have a slightly different mode choice profile in the first place, with much lower car use. It is not clear from UITP (1998) why this is, but one has to ask whether the control group included people aspiring to greater car use, where as the target group generally did not have such aspirations.

Table 9c IndiMark® Results from Lisboa – percentage using each mode

Mode	Before		After	
	Target	Control	Target	Control
Walk & Bicycle	7	12	7	8
Motorbike	2	1	3	1
Car as driver	59	40	52	44
Car as passenger	9	8	10	9
Public Transport	2	37	25	35
Other*	3	2	9	4

Note: *includes taxi, employer transport, and P&R.
Source: UITP, 1998.

3.4.1.2 Gaps in modelling marketing campaigns

The whole area of awareness campaigns has not really been tackled in modelling as yet. Whilst the mechanisms exist in the models – to increase the attractiveness of a given mode for a subset of the population the main barrier has been evidence on elasticities of demand. The evidence above suggests that car trips can be reduced by between 3% and 15% but generally at the lower end. Reductions in distance travelled have a similar range, but in the UK are around 5%. The gap in modelling terms then is:-

SA1. To introduce the impact of marketing campaigns

4 Other issues

Other issues regarding model use and presentation of outputs were raised in the initial questionnaire. In addition other sub-projects within DISTILLATE have raised requirements on the use of models within project F.

Project C – on indicators has reviewed which indicators are of most use to local authorities and has produced a short list which cover the shared priorities as follows :-

Four Shared Priorities		**Indicator**
Air Quality	1	CO_2 emissions
	2	Change in area wide road mileage (area wide CO_2 emissions)
Potential extras		*PM*
		NO_X
Congestion	3	Average time lost per Vehicle km
Safety	4	Total KSI
	5	Total Casualty Rate
Accessibility	6	Public Transport Patronage
	7	Journey Time taken to key services by PT
	8	Real changes in the Cost of PT
	9	PT options available to key services

Table 10 : Project C short listed indicators.

Where possible the modelling case studies will report the impacts of policy instruments on the above indicators. There will of course be some case studies where other indicators are needed to demonstrate the local level impacts of the specific instruments e.g. land use indicators will be developed in conjunction with project C for the Essex case study on housing developments (see below).

Project C also highlighted the weaknesses in current approaches to target setting. We will be able to investigate this issue further with some of the modelling case studies.

Option generation has been the subject of Project B and during the initial survey it was found that this was important at both the strategic and the scheme level. Whilst models are in project B terms working inside the box i.e. they are used to look at a pre-defined set of policy instruments they can be useful in generating and assessing different combinations of these instruments. Project F will be aiding option generation in its case studies of Essex, York and Leeds using STM, STEER and MARS respectively (see below). The Essex case study will look at where to develop housing, the York one will look at optimising the combination of possible schemes to improve network management (with particular emphasis on improving bus), while the Leeds MARS model will be developed as a flight simulator to allow planners to try out strategic policies in seconds.

The other general issue which arose from the survey was that models should be easier to use and outputs should be improved. In response to this the STEER model will enhance its outputs to give network information graphically and the MARS model will be enhanced with a flight simulator front and back end with standard outputs being presented graphically and where suitable linked to a GIS package. This covers the second sub-objective of Project F which is to enhance the existing sketch planning models.

5 Definition of case studies in response to reviews

The above reviews have highlighted a number of gaps or weaknesses in the current modelling capabilities. Some of the research issues are being addressed elsewhere and/or are outside the scope of the DISTILLATE project. The aim of our project was always to identify weaknesses and then to demonstrate how to overcome these weaknesses through example applications. Obviously we are limited by the models available to the consortium and as such we cannot cover every weakness identified.

The models available to the consortium range from simulation models DRACULA and STEER, assignment model SATURN, to strategic models STM and MARS. Since the review stage we have also added PT-SATURN and a Heavy Rail model (an elasticity based model developed for West Yorkshire) to our list of available models. This allows us to cover the whole range of modelling techniques within our case studies. The following sections detail the case studies being conducted under project F by model relating each element of the model enhancements to the above reviews. In this way we demonstrate the link back to the gaps identified at the review stage.

5.1 MARS case studies

MARS is a strategic LUTI model available for Leeds within DISTILLATE. Table 11 shows the detailed changes or study elements being developed within the MARS approach. As can be seen some are small changes to the model e.g. to include a public transport over-crowding model while others are more substantial e.g. to include a fourth mode and pull in more detailed data from a Heavy Rail demand model or to add a household transition and ageing model to the land use model.

Table 11 : Case Study details for MARS.

Theme	MARS –Leeds
Demand restraint policies	M1 – Parking capacity – change model to reflect parking capacity and impact on parking place search times. M2 – Adding congestion function to the off-peak M3 – Link between MARS and SATURN to better represent congestion and charging effects in MARS.
Public transport improvements	M4- Heavy Rail – addition of fourth mode and link to more detailed supply model M5 – Public transport over-crowding model for bus and rail M6 – Effects of reliability, branded networks, marketing, safety and security
Land use policies	M7 – Transfer of current land use model to VENSIM M8- Introduction of Ageing model and demographics/household transition model impacting on trip rates over time.
Soft/attitudinal policies	M9- Individualised marketing schemes using evidence from review to change subjective valuation factors. M10 – Simple Telework implementation based on evidence of reduced commute trips (To be improved with input from PhD student)
Slow modes/small schemes	M11 – Test changes to evaluation approaches – including slow mode time savings/health impacts M12 – Improve slow mode –car interactions using mirco-simulation and evidence based studies
Enhanced user interface/outputs	M13 – Develop “Flight Simulator” approach and user interface for data files using VENSIM platform. This will enable the user to “play” with policies and view outputs in graphical/tabular form – links to GIS package.
Project B	Option generation – via “flight simulator” approach. We will also test the optimisation facilities available in VENSIM to produce an “optimal” strategy.
Project C	Develop indicators consistent with local authority requirements as suggested by Project C. Investigate target setting issues.

This set of enhancements covers the gaps D4, D12, PT15, PT16, SA1 and other issues from section 4 related to enhancement of the sketch planning tool and requirements from projects B and C.

5.2 SATURN and PT-SATURN case studies

The SATURN case studies draw mainly on the review of demand restraint policies. The case studies will be studied for local networks of Leeds and Harrogate but transfer in issues from other areas e.g. issues raised by Strathclyde and Stockport about the modelling of parking capacity and its impact on choice of car park, possibilities for modelling WPPL in response to Nottingham’s concerns and the improvement of park and ride representation in response to York. Two more case studies are included in response to the reviews – one related to modelling road pricing in general and one using PT-SATURN to look at how best to model quality bus schemes.

Table 12 : Case Study details for SATURN and PT-SATURN.

Theme	SATURN – Leeds/Harrogate
Demand restraint policies	S1 - Modelling of parking capacity and its impact on car-park choice using multiple time periods to model the take up of capacity. S2 - WPPL : Based on issues from Nottingham case study. S3 - Park and ride : improved models using experience from York and the idea of super networks (this is linked to the parking model issue) S4 – Modelling area based charging and pricing more generally. S5 – Improved representation of delay in buffer networks S6 – Improve scheme design methodology
Public transport improvements	S7 – Quality bus schemes using PT-SATURN importing new parameters from evidence
Land use policies	N/A
Soft/attitudinal policies	N/A
Slow modes/small schemes	N/A
Enhanced user interface/outputs	N/A
Project B	N/A
Project C	Check local level indicators with Project C

This set of enhancements covers the gaps D1, D4, D10, D12, D13, D14, PT10, PT11

5.3 DRACULA case studies

DRACULA is a micro-simulation model capable of modelling individual vehicle movements for both car and bus. Recent work has involved importing public transport routes from PT-SATURN. We intend to build on this research to look at the dynamic modelling of public transport users' route choice and the effect of modelling capacity of bus routes. This will be conducted as a theoretical exercise using a hypothetical network to allow us to develop the algorithms. Future work could be to apply the algorithms developed to larger real networks but we are not committing to this within DISTILLATE.

Table 13 : Case Study details for DRACULA.

Theme	DRACULA – Hypothetical Network
Demand restraint policies	N/A
Public transport improvements	DR1 – Public Transport Users' route choice and capacity constraints
Land use policies	N/A
Soft/attitudinal policies	
Slow modes/small schemes	
Enhanced user interface/outputs	
Project B	N/A
Project C	Makes use of indicators of reliability/punctuality.

This case study covers the issue of modelling capacity of buses and the effect on users' route choice at the operational/network level i.e. gaps PT13 and PT14.

5.4 STEER case study

STEER is a micro-simulation model that specialises in "whole city" tests of bus and car effects of proposed actions. Recent work has involved inputting an accurate set of bus routes and frequencies for York. We intend to investigate which measures are best at improving bus journey time without unduly penalising cars.

A range of instruments will be considered in the case study building on work for the Local Authority by Halcrows. These include

- bridge closures to car traffic,
- bus priority measures through bus lanes and signals,
- bus design, route and frequency changes, and
- network management schemes for both car and slow modes.

Apart from the model enhancements listed below the main emphasis of the York case study will be to look at the problem of selecting the optimal combination of schemes from the above list (note there are over 250 thousand possible combinations).

Table 14: Case Study details for STEER

Theme	STEER – York
Demand restraint policies	ST1 Closing roads and bridges. ST2 Changes to capacity/prices especially to benefit buses. ST3 Implementing G/A in micro-simulation environment. Simple testing for optimisation of prices and/or capacities.
Public transport improvements	
Land use policies	N/A
Soft/attitudinal policies	
Slow modes/small schemes	
Enhanced user interface/outputs	ST4 – Enhance graphical interface including a possible connection to mapping technology at SEI.
Project B	Design a method for solving the combinatorial optimisation problem to generate best combination of schemes – scheme design. Test on very simple cases.
Project C	Define indicators for objectives in line with Project C review.

The main gap covered here is related to project B – generating the best combination of schemes but others include D4, D6, D14, and user interface improvements.

5.5 STM case studies

TRL's strategic transport model (STM) is a multi-modal planning sketch model which uses simplified route assumptions and speed/flow techniques to represent congestion effects on the highway network and thereby avoids the use of time-consuming full assignment techniques. Within DISTILLATE it provides the modelling platform for Project F case studies in Strathclyde and Essex. STM obtains planning data either as exogenous user-supplied inputs or by running with an external land-use model such as DELTA (as in the Strathclyde SITLUM system). The Strathclyde STM will be used to develop better techniques for sketch modelling of modal interchange using data from the Scottish Household Survey and outputs from the large scale network model SITM4 (Strathclyde Integrated Transport Model). For the Essex case study, the Chelmsford STM is to be used as the platform for new techniques to model housing development scenarios and to optimise the location of developments.

Table 15 : Case Study details for STM.

Theme	STM – Essex and Strathclyde
Demand restraint policies	STM1 - Parking capacity modelling at Subway stations (Strathclyde) STM2 - Improved congestion modelling at development sites (Essex)
Public transport improvements	STM3 - Explicit representation of Subway stations / park and ride (Strathclyde) STM4 - Representation of public transport links to development (Essex)
Land use policies	STM5 - Modelling of new housing developments (Essex)
Soft/attitudinal policies	STM6 - Possible life style effects on trip making (Essex) STM7 - Possible interchange quality effects (Strathclyde)
Slow modes/small schemes	STM8 - Walk access modelling to Subway (Strathclyde) STM9 - Generated walk trips at developments
Enhanced user interface/outputs	STM10 – Outputs for Subway station use (Strathclyde) STM11 – Land-use outputs relating to developments (Essex)
Project B	STM 12 – Generation of development options for Essex and automated optimisation of combinations.
Project C	Link to Surrey case study in Project C

These case studies cover gaps in demand restraint, public transport representation and land use developments in strategic models looking specifically at where to locate new housing. The gaps covered include D4, D10, D12, PT15.

5.6 Heavy rail demand model case studies

The heavy rail demand model is a spreadsheet model which was originally developed for Metro (Leeds PTE) in 2002 by Atkins consultants. Subsequent work was carried out jointly by JMP Consultants and ITS (University of Leeds) in 2003 for the PTE's as a response to OPRAF investigation of the feasibility of local rail services. The model is static but has several stages.

The first stage sees the collection of current data which is used to populate the model, with the following being collected for the six lines of the local heavy rail network and their catchment areas:

- Current base demand from observed data;
- Current train scheduling;
- Current operating costs;
- Current socio-economic conditions (i.e. employment, population etc.)

The second stage uses a series of elasticities and diversion factors to calculate current journeys between the catchment areas and Leeds city centre and the modal split that ensues. This results in forecasts of the following for both the peak and off-peak;

- Rail journeys
- Car journeys
- Bus journeys

The third stage uses the new forecasts to calculate:

- Changes in environmental costs – air, noise & accident;
- Changes in revenues and costs – rail and bus operators.
- Changes in congestion – car & bus users.
- Changes in taxes – government.
- Changes in consumer and producer surpluses.

It is possible to run a number of different scenarios by changing factors in either the first or second stages. Details of possible scenarios include enhancements to rolling stock, new stations, changes in journey times, changes in operating costs; changes in frequency; substitution and overcrowding.

With regards to case studies we see the scope for linking the heavy rail demand model with MARS as outlined in M4 above. We also envisage useful links back from MARS to the rail model to improve forecasts and to take account of non-rail policy interventions. There is also scope for enhancing the capability of the current heavy rail model by improving the mode choice procedures within it and possibly introducing more dynamic elements into it.

Table 16 : Case study details for Heavy Rail

Theme	Heavy Demand Rail Model – West Yorkshire
Demand restraint measures	N.A. (Apart from feedback from MARS policies)
Public transport improvements	H1-Use population growth estimates from MARS to populate the spreadsheet heavy rail model. H2-Improve the mode choice element of the spreadsheet rail model, including quality and reliability impacts. H3- Feedback car and bus costs from MARS to improve representation of other modes within the rail model.
Land use measures	N.A.
Soft/attitudinal measures	N.A
Slow modes/small schemes	N.A
Enhanced user interface/outputs	N.A
Project B	N.A.
Project C	Check indicators are in line with Project C requirements

This set of enhancements covers the gaps PT1, PT2, PT3 and PT5.

6 Future case study reports

The above case studies will be reporting during 2007-2008. Each case study report will cover the following for each element identified in the above tables:-

- Aims/Objectives of the case study
- Background – model description and case study history/issues
- Enhancements to modelling methodology (with reference to literature or evidence used)
- Demonstration of enhancements by case study / policy analysis or appropriate sensitivity tests (for each element)
- Transferability of methodology to other models/areas.
- Conclusions

With this structure the case study reports will demonstrate which of the gaps identified in the reviews have been successfully overcome and whether or not they can be used elsewhere.

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