Audit of the LASER 3.0 Model Report

Table of contents

- 1. Introduction
- 2. Understanding of LASER
  - 2.1 Overview
  - 2.2 Land use model
  - 2.3 Transport model
  - 2.4 Segmentation
  - 2.5 Model calibration and validation
    - 2.5.1. Land use model
    - 2.5.2. Transport model
- 3. Case study - The effect of extra dwellings in Thames Gateway
- 4. Comparison with conventional modelling
  - 4.1. Generation and distribution
  - 4.2. Mode split
  - 4.3. Assignment
  - 4.4. Assessment against current DfT guidance
    - 4.4.1. Time periods
    - 4.4.2. Incremental vs synthetic modelling
    - 4.4.3. Hierarchy of responses
    - 4.4.4. Assignment
- 5. Consultation with LASER customers
- 6. Technical Review and Recommendations for Improvement
  - 6.1 Conclusions from Technical Review
  - 6.2. Recommendations for improvement
- 7. Implications for HA strategy/development control
  - 7.1. Development Control
  - 7.2. Policy and Strategy
  - 7.3 Conclusions
- Appendix A: Review of LASER by RAND Europe
  - A.1 Residential location choice
  - A.2 Firm location choice
  - A.3. General comments on LASER
1. Introduction

In October 2002, the Highways Agency appointed Mott MacDonald to provide specialist technical support in traffic, transportation and economics for a 3 year period. In a letter dated 05 February 2004, we were asked to submit proposals to review the assumptions, operation and outputs associated with the London And South East Regional land use and transport model (LASER version 3.0). Following submission of a Proposal, we were asked to proceed with the work on 16 February 2004.

The following extract from the brief summarises the objective of this work:

‘The overall objective of the proposed work is to get a better understanding of the assumptions, structure and operation of the LASER model, and to get a better understanding of its outputs and applications, so that the basis of conclusions concerning the impact of new development and transport capacity, particularly on the highway side, can be more clearly seen and discussed.’

The first issue of this report was given to WSP for comments. In this issue all factual corrections have been made and their more general comments are included in Appendix B.

The remainder of this report is structured as follows:

Chapter 2: Understanding LASER: a summary of how LASER works
Chapter 3 Case Study - a comparison of two scenarios from the LASER work on Thames Gateway
Chapter 4 Comparison with Environmental Modelling
Chapter 5 Comparison with LASER Customers
Chapter 6 Technical Review and Recommendations for Improvement
Chapter 7 Implications for HA Strategy/Development Control
Appendix A: Review of LASER by RAND Europe
Appendix B: Comments from WSP Policy & Research
2. Understanding of LASER

2.1 Overview

Our understanding of the LASER model is mainly based on the following documents:

- Validation of LASER Model Report (1997)
- Transport and Development in the Thames Gateway (Phase 1 and Phase 2 reports, DfT/Mott Macdonald, February and May 2003)
- Wider South East Regional Research Study (Phase 1 and 2 draft Report)
- HA/KBR Technical Note 28.3. Lower Thames Crossing NAOMI runs report.
- HA/KBR TN40 on Thames Gateway Forecasts

Further clarification was obtained at a meeting in Cambridge on 2 March 2004 between Mott MacDonald (Ian Johnston and Andrew Gordon) and WSP (Ying Jin and Ian Elston), and through subsequent emails.

An overview of the LASER model is given in Figure 2.1. The individual components of the model are discussed below. The intention is to give a broad overview of the structure and operation of the model, and of what it does and does not model, in order to help understanding of model outputs. More technical details can be found in Jin et al (2002) and the LASER Enhancement Report.

There is an important distinction between exogenous and endogenous data. The former are input by the user and are fixed for the model run; they are indicated by a shaded background in Figure 2.1. The latter are calculated by the model. The different types of data are discussed in the sections below.

LASER can be divided into two parts: a land use model and a transport model.

A number of feedback loops operate within the model, requiring a certain amount of iteration to convergence:

Within the land-use model:

- Between household location and housing cost (congestion rent)
- Between household location and some employment (local services and education)

Within the transport model:

- Between assignment and mode choice

Between land-use and transport models:

- Costs are passed from the transport model to land use model. This loop is carried out three times.
Each step within the model is described in more detail below.

2.2 Land use model

2.2.1 Overview

The land use component of LASER estimates the location of employed households and travel demand arising from all residents. The LASER travel demand estimation replaces the generation and distribution stages of a conventional four-stage model. The following sections discuss the various parts of this component.

However, it should be noted that the following trip matrices are not part of the land use modelling:

- Freight
- Non-commuting travel with one trip end outside the study area
- Through traffic between regions outside the study area
- Light and heavy goods vehicle movements and passenger trips to/from major airports are input exogenously into LASER.

2.2.2. Employment location

The majority of employment location (86%) is an exogenous input to the model and therefore fixed for a given model run. It is defined as the number of employed workers per zone for 9 industrial sectors. For these industrial sectors, LASER does not alter the number of workers in a zone in response to changes in travel costs. Alternative employment location scenarios must be tested by changing the employment inputs exogenously.

The remaining 14% consists of 2 industrial sectors (local education and service employment). The model calculates the location and amount of this employment as a function of the location of the households which it will serve. This employment in turn generates employed households which in turn create local employment so there is a feedback loop between the location of local education and service employment and household location.

2.2.3. Household location

The following exogenous data are input by the model user and are fixed throughout a given model run:

- The number of economically inactive households, e.g. unemployed and retired, for each zone
- The total number of dwellings (the housing supply) in each zone

The first step carried out by LASER is to take the employment location (measured in employed workers per zone by industry) data from the employment location model and convert it into a demand by employers for employed residents. These employed residents subsequently form household units. Households are categorised according to the SEG of the head, the number of adults within a household, and car ownership.
The home zone location of these households is determined by a logit distribution model (calibrated to 1991 data) that takes into account the following components of generalised cost:

- Cost of commuting from home zone to work zone
- Cost of living in the home zone (including housing costs)
- Zonal attractiveness constant
- A spatial impedance cost additional to travel costs

Only the first two components are allowed to change over time. The last component is the equivalent of the K factors that are sometimes included in an incremental distribution model to obtain a better fit between modelled and observed base trip matrices.

The supply of housing (number of dwellings per zone) influences household location through the calculation of the so-called congestion rent. This represents the change in rent caused by changes in the balance of housing supply and demand between the base year and forecast year.

There is no hard capacity to prevent the number of households exceeding the number of dwellings in each zone; it is assumed that households will share dwellings. When this happens the congestion rent will increase and the zone will become less attractive.

The attractiveness of zones is represented by a Base Year zonal constant for each household category. There is no segmentation of housing by type/quality, so suitability of housing stock to different households is not modelled. The zonal attractiveness constant remains fixed in forecasting mode. The effect of, for example, ‘gentrification’ (where the mix of housing radically changes) cannot be forecast by the model. The zonal attractiveness constant can only be modified if the target of the planned change (e.g. gentrification) is input into the model.

2.2.4 Trip generation and distribution

(1) Commute

From the housing location model LASER knows the home and work locations of each worker. A production-attraction trip matrix is then calculated by applying a trip rate to each worker. These trip rates are calculated from NTS.

(11) Other personal

Once the location of employment and households has been determined, the generation and distribution of trips for non-commute purposes follows a method that does not differ significantly from any standard four-stage model.

Trip generation is calculated by person type and trip purpose using data from NTS. Trip distribution is a standard singly-constrained (at the generation end) distribution using a logit model. In addition to travel costs the generalised cost function includes the zonal attractiveness constant for the attraction zone. Attraction zone size variables by purpose are also used, as shown in Table 2.1
Table 2.1: Attraction variables used in distribution of non-commute purposes.

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Attraction/size variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education</td>
<td>No. of dwellings (proxy for size of community)</td>
</tr>
<tr>
<td>Shopping and other personal</td>
<td>Retail employees x 20 (estimate of retail floorspace)</td>
</tr>
<tr>
<td>Employer’s business</td>
<td>No. of employees working in offices</td>
</tr>
</tbody>
</table>

**111) Freight and external trips**

The remaining trip matrices are an exogenous input to the model, i.e.:

- Goods vehicles: LGV and OGV (from the Orbit project; updated to include new ports areas in recent applications (after Thames Gateway tests))
- Passenger and escort trips to and from main London airports (from SERAS, with updates)

Non-commute trips in and out of the LASER area are excluded from the model.

**2.2.5. P/A to O/D matrices**

The final step of the land-use model is to convert the production-attraction (P/A) matrices output by the above stages to origin-destination (O/D) matrices for use in the transport model.

A P/A matrix represents trips according to the production or generation location (usually the household for home-based trips) and the trip attractor (e.g. the workplace for commute trips). For example, a commute trip would be represented as a single entry in a P/A matrix from the household zone to the workplace zone. P/A matrices typically represent a 24 hour period.

The above entry in the P/A matrix needs to be converted to O/D level and allocated to a time period for assignment. A single home-based P/A trip is turned into two trips: one with the origin in the household zone and destination in the workplace zone and the return journey with the origin in the workplace zone and the destination in the household zone. For example, most home to work trips occur in the AM peak and most work to home trips in the PM peak.

**2.3 Transport model**

**2.3.1. Overview**

In LASER the transport model consists of mode choice and assignment.
2.3.2. Mode choice

Mode choice in LASER is a standard multi-nomial hierarchical logit model. The utility function (generalised cost) consists of travel time, out of pocket expenses, a destination disutility (e.g. to represent the inconvenience of parking) and a mode-specific constant.

Separate models are used for inter and intra-zonal trips.

All main passenger modes are considered: car, bus, coach, rail, underground and walk/cycle. See Table 2 for details of the other segmentation in the model.

Mode choice is not applied to the exogenous trip matrices (i.e. road freight and airport passenger travel).

2.3.3. Assignment

(1) Networks

The highway network is based on the NAOMI network, which is much more detailed than the network used in previous versions of LASER. NAOMI is a SATURN network with junction simulation. LASER has the same road links as in NAOMI, with the road capacity restraints being simulated using simpler, link-based speed-flow curves rather than explicit modelling of the junctions. A variety of network data has been converted from the NAOMI road network data to the MEPLAN link-based modelling system (e.g. free-flow times and effective capacities). This means that LASER does not explicitly represent junction delays, a highly significant source of congestion in urban areas, although the comparison of congested speeds on the trunk roads appear to be compatible with NAOMI for the validation year (1997). The accuracy of such approximations, however, tends to decrease the further into the future the model is used to forecast as changing traffic patterns alter the effective link capacities which remain fixed in the model.

The surface rail network is based on PLANET (which is SRA’s rail model) but the underground network and station access and transfer data is updated from the previous version of LASER. The LASER underground network is less detailed than PLANET because similar services are amalgamated, but the service capacities represented in LASER are consistent with PLANET. Overcrowding is modelled through a multiplier on the value of travel time.

Buses are modelled as part of the traffic on the highway network (i.e. assigned together with cars and goods vehicles, and subject to road congestion). Bus routes and services are generally not modelled, except a small number of new bus/coach routes specified in policy scenarios. Buses are assigned to a subset of the road network (e.g. they do not use motorways), and coaches are concentrated on fast trunk routes where available.

(11) Route choice

Traffic is assigned to the highway network using a stochastic user equilibrium (SUE) method. The SUE method included in the MEPLAN-based LASER model is completely different from the earlier stochastic methods for assignment, e.g. Burrell’s method. Rather than assuming that all routes used by a particular origin-destination pair have the same cost (i.e. Wardrop equilibrium) this method distributes traffic over a number of routes, all of which may have different costs. The lower generalised cost routes will attract more flow. The SUE method as implemented in MEPLAN is used to represent multiple routes between
OD pairs arising from individual preferences (e.g. on alternative rural routes with little congestion), as well as under congestion (i.e. in urban areas).

Rail and bus users are similarly assigned using the multi-path, stochastic user equilibrium procedure, based on travel time. Rail crowding and road congestion are respectively taken account of.

2.4 Segmentation

The levels of segmentation used in different parts of the model are given in Table 2.2.

Table 2.2: Segmentation in LASER.

<table>
<thead>
<tr>
<th>Model component</th>
<th>Segmentation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry demand for workers</td>
<td>Industrial sector (9 exogenous and 2 endogenous; 11 in total)</td>
</tr>
<tr>
<td>Employed residents</td>
<td>SEG (4) x HH size (2) x car ownership (3), 20 in total</td>
</tr>
<tr>
<td>Spatial distribution of employed residents</td>
<td>as above</td>
</tr>
<tr>
<td>HH formation/housing demand</td>
<td>SEG of head(4) x HH size (2) x car ownership (3), 20 for employed households and 10 for economically inactive</td>
</tr>
<tr>
<td>Generation &amp; distribution (non-commute, non-EB)</td>
<td>Purpose (3) x income ( \text{8} ) (2) x car access (3) x age band/economic status (5), 18 in total</td>
</tr>
<tr>
<td>Generation &amp; distribution (EB)</td>
<td>Local services ( \text{9} / \text{Professional/managerial travel} )</td>
</tr>
<tr>
<td>Mode split</td>
<td>Purpose (4) x income (2) x car access, 19 in total</td>
</tr>
<tr>
<td>Assignment</td>
<td>User mode (private car, business car, bus, coach, rail, underground)</td>
</tr>
</tbody>
</table>

2.5 Model calibration and validation

The base year for the calibration of LASER 3.0 is 1991, making use of the wide range of data sets that are available for that census year. However, use was also made of data before and after that year where 1991 data on its own was considered inadequate for calibration.

LASER has also been validated by running it in forecasting mode for 1997 and comparing the results with observed data. This is a valuable exercise as there are very few models that have been validated in forecasting mode.
At the moment DfT validation criteria exist only for assignment models. The quality of the validation of the demand models is therefore only based on our judgement of the quality of the synthesised model results compared with observations.

### 2.5.1. Land use model

Details of the data used in the calibration of the 1991 model can be found in the LASER Enhancement Report. As with most models the calibration process ensures that there is a good match between the model predictions and the calibration data (such as the location of households). The generalised travel costs and housing expenditure are included as explanatory variables, and other factors affecting household location are represented by constants by zone and household type. These constants improve the goodness of fit of the calibrated model.

Additional verification checks against independent data were carried out for the output trip matrices for 1991 as follows:

- Comparison of modelled trip length distribution by demand segment with NTS: there is generally a good match between modelled and observed, particularly for commute trips, although for non-commute trips there is a tendency for the model to underpredict the proportion of trips in range around 8-20km. The model output is compared with the NTS average for 1988-1996, because the NTS sample for individual years is too small by demand segment.
- Comparison of commute trip matrix with 1991 Census Journey to Work matrix: the former was factored to have the same number of trips as the latter so this is a test of the distribution, not the actual trip numbers (which cannot be obtained from the JTW data). The comparison is presented as the ratio of cell values in a 6-sector matrix. At this level, the OD cells with most of the trips compare well. There is a significant difference in a few cells, but these represent 1.3% of total trips. It may be that a comparison at a more detailed spatial level would reveal more significant differences.

Validation of the land use model in 1997 forecast mode is slightly hindered by the fact that it is not a census year and therefore there is not the same amount of data available as was used for validation in 1991. In many cases only estimates used by NTEM are available. The key comparisons are:

- Endogenous employment (local retail and education): comparison of total modelled retail and education with NTEM data. There is a good match for retail; the match for education is less good. WSP identify this as indicating a need to improve this part of LASER.
- Household location: comparison of number of households by zone by car ownership and HH structure with NTEM estimates. The comparison is good, demonstrating consistency between LASER and the NTEM estimates.
- Comparison of modelled trip length distribution by demand segment and by purpose with NTS: very similar to the comparisons done for 1991. NTS and LASER both show an increase in mean trip length. Commuting has a reasonably good match, but LASER overestimates the amount of increase for Other Private trips (NTS=-0.7%, LASER=6.1%).

Since the land use model operates before mode choice these comparisons are done for `all mode` matrices. In principle the model could also be run in forecast mode for 2001 for comparison with the latest Census data, although data from Census 2001 was not available at the time of model validation.
2.5.2. Transport model

(1) Mode choice

The mode choice model was calibrated using London Area Transport Survey (LATS) 1991 and National Travel Survey (NTS) data. The goodness of fit for the resulting models (model compared with calibration data) is generally good. Results from the calibration process can be used to calculate the implied values of time used in the model; these seem sensible. Comparison with NTS data (averaged between 1988 and 1996) gives a good match, albeit with a few anomalies:

- LASER overestimates the share of non-mechanised modes for education (52% vs 45%) and 'other private' purposes (44% vs 35%). This is probably due to the overestimation of short trips for these purposes in the land use model
- LASER overestimates the rail share for white collar EB trips (21% vs 9%), at the expense of car travel (This was later improved in the Thames Gateway Study)

The output commute matrices by mode were also compared with the Census Journey to Work by mode at the 6-sector level (as was done for the all mode commute matrix for the land use model). The modal comparisons showed significant differences, but this is because the Census modal matrices were less reliable than the all-mode matrices, and for this reason could not be used as data for model validation.

(11) Assignment

In the LASER Enhancement Report highway link flow validation for 1991 is presented for 3 cordons/screenlines in each direction. The same flows are also presented for 1997, with the added complication that there are two sources for the observed data, the NARNAS database and data provided by the KBR NAOMI team. The results are summarised in Table 2.3.

Table 2.3. LASER highway flow validation.

<table>
<thead>
<tr>
<th>Screenline/cordon</th>
<th>Direction</th>
<th>1991 NARNAS</th>
<th>1997 NARNAS</th>
<th>1997 KBR</th>
</tr>
</thead>
<tbody>
<tr>
<td>M25</td>
<td>Anticlockwise</td>
<td>13%</td>
<td>16%</td>
<td>30%</td>
</tr>
<tr>
<td></td>
<td>Clockwise</td>
<td>14%</td>
<td>22%</td>
<td>25%</td>
</tr>
<tr>
<td>M25 cordon</td>
<td>In</td>
<td>7%</td>
<td>16%</td>
<td>1%</td>
</tr>
<tr>
<td></td>
<td>Out</td>
<td>-14%</td>
<td>-11%</td>
<td>-17%</td>
</tr>
<tr>
<td>Bridges</td>
<td>North</td>
<td>10%</td>
<td>11%</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>South</td>
<td>-8%</td>
<td>-7%</td>
<td>-</td>
</tr>
</tbody>
</table>

It can be seen that virtually all of these exceed the Â±5% criterion recommended by DMRB. Inbound flows are overpredicted and outbound are underpredicted.
As would be expected individual link flow validation is even worse, with differences of at least 50% on some links (although these are non-trunk roads). Figures showing a link by link comparison can be found on pp95-97 (for 1991) and pp110-115 (for 1997) of the LASER Enhancement Report (see Chapter 2 for the link to download this report).

The journey time validation work carried out in the Orbit Project shows the road journey times modelled by LASER for 1997/98 (which is a forecast year for LASER) fit better than NAOMI on average, although there is more variability among the links. More detail is contained in the Orbit Model Validation Report.

2.5.3. Elasticities

LASER model runs were carried out to calculate modelled elasticities (short and long-term) of passenger kms with respect to PT fares and car fuel costs. These were compared to benchmark values provided by the ORBIT project, and in the wider literature. The LASER modelled elasticities fall within the benchmark ranges, generally towards the lower end of the range. This is expected because the average income in the LASER area is higher than what is assumed by the benchmark values. (For details of this comparison see Jin et al, 2002).

Figure 2.1: LASER Overview Please click here link to view figure2.1: LASER Overview

3. The LASER study area is defined as the combination of London, and the government office regions of South East and East of England
4. The number of jobs is not the same as the number of workers due to, for example, part time workers with more than one job
5. LASER makes no distinction between tenants and owner-occupiers in calculating housing costs. No account is taken of the effect of changes in interest rates and mortgage availability on house prices.
6. See section 0 for an explanation of this term
8. There is a many-to-one mapping from SEG to income
9. Local service trips are replaced by the exogenous LGV matrix
10. National Trip End Model
11. Others are given in the LASER enhancement report
3. Case study - The effect of extra dwellings in Thames Gateway

To gain further understanding of the way LASER works we have carried out a detailed comparison of two 2016 scenarios from the Mott MacDonald Thames Gateway Study, A3 and A4. In summary these scenarios consist of the land use and transport assumptions shown in Table 3.1.

Table 3.1: Land use and transport assumptions for Thames Gateway scenarios (input data).

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Land Use (extra compared with 2001)</th>
<th>Transport</th>
</tr>
</thead>
<tbody>
<tr>
<td>A3</td>
<td>Mid growth 2016 (120 000 dwellings, 200 000 jobs)</td>
<td>Committed schemes</td>
</tr>
<tr>
<td>A4</td>
<td>High dwelling growth, mid employment growth 2016 (180 000 dwellings, 200 000 jobs)</td>
<td>Committed schemes</td>
</tr>
</tbody>
</table>

Scenarios A3 and A4 are among a number of model tests, in which housing and/or employment growth are varied in order to test how levels of employment or housing supply would affect household location and traffic. A3 assumes house building as proposed by the Sustainable Communities Plan (which has already increased housing construction by 50% from the RPG9 levels). A4 adds an extra 60 000 dwellings, distributed throughout the Thames Gateway area, which is well above the market expectations. To put this into context the Thames Gateway (TG) area has 810 000 dwellings in A3 (2016), i.e. there is an increase of 7.4% in A4. In A3 there are 774 000 households in TG.

A priori it is difficult to say what the overall impact of the extra houses in A4 would be on traffic. The extra housing could allow workers to live nearer to their jobs, hence reducing overall vehicle kilometres; alternatively the extra workers attracted by the reduced housing costs in the Thames Gateway (as a consequence of the increased supply) could end up travelling longer distances to work, increasing overall vehicle kilometres.

In summary the main impacts of the extra houses (A4 results compared with A3) are:

- Fall in congestion rent of an average of 3.1% in TG
- 4% increase in trips (all modes) originating from TG; 6% increase for rail/LU; 3% increase for car
- 1% increase in average trip lengths (all modes); 0.3% for rail/LU and car
- 4.5% increase in passenger kilometres (all modes)
- An extra 23 000 households (3%) in TG (i.e. the majority of the extra 60 000 dwellings are not occupied), offset by a corresponding decrease outside TG

(Taken from ‘Transport Development in the Thames Gateway Phase 2 Final Report’)

To expand on the last point, the occupancy rate of the extra housing (expressed as the number of extra households divided by the number of extra dwellings) varies between TG zones. In zones with little or no extra dwellings in A4 compared with A3 there is a reduction in households as they are attracted to cheaper housing elsewhere in TG. On the other hand some zones have an occupancy rate of over 70% for the extra dwellings (i.e. Greenwich (NW), Swanscombe, Thurrock (E), and Tilbury).
Further analysis of the results focuses on commuting trips. Table 3.2 shows the change in the number of commuting trips between the two scenarios. As might be expected the 23,000 extra households lead to more commute trips from the TG area. The figure of 22,625 extra trips implies a commute trip rate of 0.98 trips/household. This is higher than the average trip rate (see section 4.1) because the way LASER works means all of the extra households in A4 contain employed residents whereas the average reported later is across all households, including economically inactive ones.

Because the total number of jobs is the same in both scenarios there is a corresponding decrease in trips from outside TG.

The majority of employment location is fixed so the destination of commute trips is largely unchanged. The extra 2,322 trips with a destination in TG can be attributed to the increase in local education and service employment predicted by the model in response to the extra households.

Table 3.2: Increase in commute trips, person trips, thousands (A4 minus A3)

<table>
<thead>
<tr>
<th>From</th>
<th>To Thames Gateway</th>
<th>To Rest of LASER Area</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thames Gateway</td>
<td>+8.6</td>
<td>+14.0</td>
<td>+22.6</td>
</tr>
<tr>
<td>Rest of LASER Area</td>
<td>-6.3</td>
<td>-16.4</td>
<td>-22.7</td>
</tr>
<tr>
<td>All</td>
<td>+2.2</td>
<td>-2.4</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Table 3.3 shows car only commute trips by trip origin, and identifies the number of intra-zonal trips. Note that the extra 12,000 car trips from TG compares with 22,600 all mode trips, i.e. a 53% mode share for car. By contrast TEMPRO gives an average 65% car share for commute trips generated in the TG local authorities in 2016, although the geographical area for the TEMPRO figure is not the same as that reported by LASER results. It is also below the average LASER commute car mode share in TG of 63% (see Table 3.1).

The additional housing is assumed to be distributed in the vicinity of public transport (particularly fast rail) nodes in the area, which have good connections to Central London and Docklands employment centres. This seems to have had an effect on mode share for trips originating from Thames Gateway. The TEMPRO mode share does not take account of the housing location strategy.

It should also be noted that LASER forecasts a high level of congestion on the trunk roads in both Scenarios A3 and A4. The low growth in car traffic is in part due to the further road traffic being choked off (i.e. the households respond to congestion through residential location, trip distribution and mode choice, as well as route choice).

Table 3.3: Car commute trips by origin, person trips, thousands (A4 minus A3)

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There are therefore only an additional 9,000 inter-zonal car commute trips generated by the 60,000 extra dwellings, offset by a decrease from the rest of the model area. However, the impact of these, and any extra non-commute trips, on the strategic road network is very limited as shown by Table 3.4 and 3.5.

Table 3.4: Total vehicle flows by screenline/cordon (AM peak total pcus).

<table>
<thead>
<tr>
<th>Screenline/cordon</th>
<th>Direction</th>
<th>A3</th>
<th>A4</th>
<th>A4-A3</th>
</tr>
</thead>
<tbody>
<tr>
<td>River Crossing</td>
<td>North</td>
<td>41,750</td>
<td>41,777</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>South</td>
<td>33,427</td>
<td>33,327</td>
<td>-100</td>
</tr>
</tbody>
</table>

Table 3.5: Link flows in the vicinity of Thames Gateway (AM peak total pcus).

<table>
<thead>
<tr>
<th>Link</th>
<th>Direction</th>
<th>A3</th>
<th>A4</th>
<th>A4-A3</th>
</tr>
</thead>
<tbody>
<tr>
<td>A13 Barking</td>
<td>East</td>
<td>8,824</td>
<td>8,775</td>
<td>-49</td>
</tr>
<tr>
<td></td>
<td>West</td>
<td>16,800</td>
<td>16,977</td>
<td>177</td>
</tr>
<tr>
<td>A2 east of M25</td>
<td>East</td>
<td>15,406</td>
<td>14,892</td>
<td>-514</td>
</tr>
<tr>
<td></td>
<td>West</td>
<td>22,516</td>
<td>23,141</td>
<td>625</td>
</tr>
</tbody>
</table>

The changes in individual link flows are small. WSP have stated that the transport model is run to a good level of convergence so link load changes greater than +1% or less than -1% should be regarded as a genuine signal rather than noise.

In summary the minimal traffic impact of the proposed 60,000 extra houses in Thames Gateway under A4 compared with A3 is a result of the following factors:

- Only 23,000 of the houses are occupied. The model indicates that there is weak demand for further housing supply in Thames Gateway over and above those proposed by the Sustainable Communities Plan (which has already increased housing construction by 50% from the RPG9 levels)
- Nearly half the extra commute trips generated are by PT and non-mechanised modes, and mode share for car is relatively low. This reflects the location of housing close to public transport nodes and the high level of road congestion.
- There is a decrease in trips originating outside the Thames Gateway area to compensate the increase of households within the area
See Table 3-2 of the Thames Gateway Phase 2 report for a full list (see Chapter 0 for web site link)

These are person trips and include both car drivers and passengers

Based on the following authorities: Barking & Dagenham, Bexley, Greenwich, Havering, Lewisham, Newham, Redbridge, Tower Hamlets, Dartford, Gravesham, Medway Towns, Swale, Basildon, Castle Point, Rochford, Southend. All of these include LASER TG zones, but also include large areas outside TG.

We do not have precise numbers for these.

4. Comparison with conventional modelling

4.1. Generation and distribution

Strictly speaking, LASER does not model how floorspace supply responds to transport cost changes. For a given run, the supply of housing, and the majority of employment location (86%) are exogenous inputs to the model. The feature that distinguishes LASER from traditional four-stage models is that it models household location. Having done this the remaining ‘land use’ component of LASER is fairly standard. Trip generation is derived from NTS and therefore broadly consistent with TEMPRO. In simplistic terms distribution of the majority of commute trips can be seen as singly (attraction) constrained, albeit with a wider range of explanatory variables in the cost function than is usual. Distribution of other personal trip purposes uses a standard singly (generation) constrained approach.

One of the consequences of LASER modelling household location is that when new housing is built, it does not automatically assume that all housing will be fully occupied. This is illustrated by the comparison between Thames Gateway scenarios A3 and A4 where 60 000 additional houses results in only 23 000 additional households, i.e. more than half the new houses are unoccupied. This contrasts with more conventional modelling approaches where it would be normal to assume that additional housing is always occupied. If this assumption had been made for the Thames Gateway tests there would have been a much greater increase in traffic between A3 and A4.

Despite the relatively low traffic impact of the extra housing in turns out that LASER has higher commute trip rates than TEMPRO:

Table 4.1: 2016 AM peak (0700-1000) person commute trip origins per household, Thames Gateway.

<table>
<thead>
<tr>
<th>Mode</th>
<th>LASER (A3)</th>
<th>TEMPRO</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>0.73</td>
<td>0.56</td>
</tr>
<tr>
<td>Car (Driver + Passenger)</td>
<td>0.46</td>
<td>0.37</td>
</tr>
</tbody>
</table>

It should be noted that there is a difference in the definition of the Thames Gateway area between LASER and TEMPRO (see footnote 16 on page 17 for details), and in the assumed proportion of employed households (see Section 3). Nonetheless the differences are significant and warrant further investigation.
4.2. Mode split

The mode split model in LASER is a logit model, as commonly used in conventional modelling.

4.3. Assignment

There is nothing unusual about the techniques used for assignment, although we have some concerns about how they have been applied (see section 4.4.4 below).

4.4. Assessment against current DfT guidance

LASER 3.0 was developed before the publication of DfT’s draft Variable Demand Modelling Advice (VADMA). Despite this, and the fact that VADMA is not yet official advice, it is reasonable to assess the variable demand element of LASER against VADMA on the assumption that the latter represents best practice.

Unfortunately VADMA does not specifically deal with land-use transport interaction models and the current guidance on Webtag is rather discursive and does not set out specific criteria for this type of model.

4.4.1. Time periods

VADMA recommends that the modelled time periods represent all traffic from the morning to the evening peaks. In LASER only the AM peak is modelled.

4.4.2. Incremental vs synthetic modelling

Unit 19 of VADMA recommends that an incremental modelling approach is used 'unless there are strong reasons for not doing so.' There are two aspects to incremental modelling: first, whether the model makes use of observed demand matrices in model calibration, and secondly, how the output demand forecasts are passed to other models:

- The LASER approach makes use of Census journey to work matrices for commuting demand modelling but is synthetic for other trip purposes. To some extent this is necessary for this type of model, because no observed demand matrices are available to cover the LASER area for non-commuting travel.
- In terms of passing demand forecast to other models, the LASER approach is incremental. It is understood that in the M25 Multimodal Corridor Study (the Orbit project), the growth rates forecast from LASER were used to adjust the NAOMI 1997 car matrix for 2016 at the OD pair level. This procedure has since been developed further in the recent Road Pricing Feasibility Study for the HA. A similar approach has been developed in the PRISM West Midlands model, where synthetic base year and future year forecasts are used to adjust validated ‘observed’ base year matrices.
4.4.3. Hierarchy of responses

Unit 23 of VADMDA notes that there is some uncertainty over the position of distribution and mode split within the choice hierarchy $^{18}$. Ideally the order of distribution and mode choice in the hierarchy would be decided by local calibration of the model and what gives the best fit to observed data. In LASER distribution appears above mode choice in the hierarchy. This order appears to have been imposed by the structure of the model, rather than on any evidence on relative sensitivities. It should be noted that current empirical data is not sufficient to determine the order of the hierarchy.

However, comparison of the concentration parameters $^{19}$ in mode choice and distribution suggests that both choices are given the same sensitivity in LASER. WSP states that the model parameters are determined by the outcome of model calibration (using LATS and NTS for modal split and the Census and NTS all-mode data for distribution), rather than implementing the model with preconceived sensitivities.

4.4.4. Assignment

A number of characteristics of the highway assignment model are different from mainstream practice in the UK:

- There is an incompatibility between the levels of details in the network and zoning systems; the former is quite detailed and the latter is, by comparison, much coarser
- The coarse zoning system, especially in the outer South East, means that a very significant proportion of trips (40% of commute trips for cars, equivalent to 14% of total car kms) is intra-zonal and does not get assigned to the network $^{20}$
- Lack of junction modelling in highly congested urban areas; this casts doubt on the ability to forecast journey times accurately, regardless of the base year validation

$^{16}$ Based on outturn trip matrix and numbers of households
$^{17}$ www.webtag.org.uk/webdocuments/3_Expert/1_Modelling/3.1.3.htm
$^{18}$ The hierarchy is essentially determined by the sensitivity of different choices to changes in cost, with more sensitive choices being lower down the hierarchy.
$^{19}$ Also known as spread or dispersion parameters, beta, theta or lambda
$^{20}$ LASER includes all trips, including those under 1 mile in length (i.e. consistent with the definition of all trips in the National Travel Survey). This may not be the case for many road traffic models, which do not include intra-zonal and other relatively short trips. The purpose of including the short trips is to model trip suppression/lengthening in a transparent way.
5. Consultation with LASER customers

The following have been contacted for their views on LASER.

DfT/ITEA Chris Smith, Mo Shahkarami

DfT/Regional Transport Division Nick Bisson/Natasha Robinson/Katie Marsh

HA/NS Jim Boud

HA/NS/Development Control Tim Harbot

HA/OD/South/DC David Stark/Douglas Rounthwaite

NAOMI Model Paul Ryder (HA), David Hardcastle/Terry Wang (KBR)

A total of 5 responses have been received. Consultees were asked to respond to the following questions:

1. A brief description of how you used LASER and the transport and/or land use schemes that were tested.
2. Were the results in line with your expectations? If any results were counter-intuitive were you able to obtain an acceptable explanation?
3. Do you have any other comments that would help us in our project?
4. Are you happy to be contacted again with any follow-up questions?

The responses are presented below as they are received. WSP have been asked to comment on the responses (See Appendix B for their comments).

- Validation is poor. This may be due to the relatively detailed network but coarse zoning system, leading to a large number of intra-zonal trips, which are not assigned.
- Lots of LASER results are counter-intuitive, e.g. extra houses in Thames Gateway do not increase traffic on the M25. One user commented that counter-intuitive results could usually be understood if thought through and discussed with WSP. Another user was more sceptical but did not provide further details.
- LASER seems to model people living closer to their work than is the case in reality. This results in overestimation of the use of non-mechanised modes and PT.
- It can be difficult to establish what the model does and how it does it - WSP do themselves no favours here.
- LASER should be praised for a number of positive aspects: more features than most other models; validation for 1997 is a test of its forecasting ability - very few models have such a test.
- One user was positive about all aspects of their use of LASER.

Given the relatively small number of responses it is difficult to draw any definitive conclusions. LASER results can be counter-intuitive, but as shown in the Case Study in Chapter 3, they can usually be understood in relation to the structure of the model.
6. Technical Review and Recommendations for Improvement

6.1 Conclusions from Technical Review

A technical review of LASER has been carried out by RAND Europe, taking into account the state of the art in land use-transport interaction models. Their full review can be found in Appendix A, and WSP’s comments on the RAND Europe review are found in Appendix B.

Here we summarise their main findings.

General comments on household location choice:

- Land use (i.e. land 'function': residential, industrial floorspace etc.) can remain unchanged for long periods of time
- There are limited empirical studies of household location choice due to the difficulties in obtaining data. However, available evidence suggests accessibility is significantly less important than other attributes of housing and the neighbourhood; this makes it difficult to quantify the effect of accessibility
- Accessibility (i.e. transport costs) is just one of many factors affecting household location choice

Relating this to LASER:

- Many of the non-accessibility factors are absorbed into the zonal constant, which does not change over time, or depends on user inputs. This is a significant simplification.
- By not differentiating between different types/quality of housing LASER cannot model the importance of this on location choice

Other comments on LASER:

- Dynamics: the time step in LASER can be very large (e.g. from 1997 to 2016 for Thames Gateway). Smaller time steps are recommended.
- Employment location: the majority of this is fixed in LASER for a given model run. This is a problem for the following reasons:
  - Company location can be more sensitive to accessibility than household location.
  - Company location can also depend on the location of residents (i.e. the potential workforce) so there is a feedback loop between company and household location.

6.2. Recommendations for improvement

The results of the review suggest the following key improvements to LASER:

- Use shorter time steps.
- In the household location model aim to reduce the size of the zonal constant by explicitly representing more of the factors that affect household choice. These can be forecast in the future, greatly enhancing the explanatory power of the model.
- Consider different types of housing by introducing segmentation into the current housing demand model. This could also help to reduce the significance of the zonal constants.
● Include a model of company location (dependent on accessibility and, possibly, household location). This could make use of the existing framework available in the MEPLAN software. Alternative implementations are presented in Appendix A.

Based on the review by RAND Europe, we can identify 3 different development paths for LASER according to its planned use:

Option 1: Use LASER like a standard transport model. In this case no changes are required, but there is a choice of other models in the region (such as NAOMI and LTS). These models have different geographic coverage and functionalities. They all have strengths and weaknesses, which need to be considered before deciding their appropriateness for a given application.

Option 2: Input commercial floorspace supply (offices, industrial floorspace etc.) so that LASER can model employment location choice in addition to its current model of residential location choice. This would require the introduction of an employment location model and improvements to the current household location choice model. This seems to represent a reasonable development path over the short to medium-term.

Option 3: Fully interactive land-use/transport model with a land market model where floorspace supply can respond to transport costs. A land market model represents a considerable extension to LASER and would represent a long-term development, if it was considered appropriate.

7. Implications for HA strategy/development control

7.1. Development Control

LASER is a strategic model. It includes large zones, a relatively coarse road network, and does not meet DMRB criteria for link flow validation in urban areas. This is not a criticism of the model, (as it is not intended to provide the detail which local models can provide) but is important in determining how outputs from the model should be used.

It is clearly not appropriate to use LASER as the sole means of determining the infrastructure required to accommodate new development. The traffic and public transport flows adjacent to the location of new development are unlikely to be well represented at an individual link level, and the details of site access and adjacent junctions are not included.

It is possible to pass the matrix changes forecast by LASER to a more local model which could provide the detail of traffic flows and junction delays adjacent to development sites, as has been done with the LASER-NAOMI link in the Orbit Project and the Road Pricing Feasibility Study. However, it will be important to understand the assumptions made by LASER before adopting this approach.

The Case Study described in Section 3 was deliberately chosen as an extreme example to demonstrate how LASER represents the responses of household location, trip distribution, and modal shifts, in addition to traffic assignment. In that example, LASER forecasts that a development of 60,000 additional houses in the Thames Gateway under a very high housing supply scenario would result in only 23,000 being occupied.
However, under typical development control situations the developer would only seek permission on the basis that the houses could be sold or rented at a price which would recover his development costs, and his calculation would be based on land and construction costs and the dynamics of the local housing market. For such development control situations, LASER should assume all dwellings are occupied, and it is capable of doing so. The series of Thames Gateway runs included one such test, where all dwellings were assumed to be fully occupied.

Nevertheless, we still need to consider if the LASER model outputs are suitable for input into a local model to determine impact for a particular development scheme.

LASER uses an iterative procedure to achieve an equilibrium solution where household location is related to commuting and housing costs, transport supply, and zonal attractiveness. However, this solution requires many different households to make decisions based on these factors and these decisions may not be made instantly. The matrix changes from LASER therefore represent a longer term situation, which is not necessarily the year of opening situation which is of interest for assessment of particular infrastructure requirements. The LASER output also relates to a particular level of infrastructure provision over a period of time which may not necessarily coincide with the year of opening of a particular scheme. If improvements are made to infrastructure as a result of a detailed local assessment, then this may differ from the LASER input assumptions. The matrix changes from LASER may therefore not be appropriate for the year of opening forecast which is required to assess the transport impact of a particular development scheme.

In conclusion, we do not believe that LASER is suitable for a detailed site access analysis, or a robust year of opening forecast, for development control purposes.

### 7.2. Policy and Strategy

Moving away from development control, the other uses of LASER are at a policy level to determine appropriate levels and location of land use activities on the basis of transport supply of all modes. These are strategic issues which can be addressed by a strategic model. In this case, it is important that choices about household location in relation to workplace are well represented by LASER (and there are areas where this can be improved). LASER assumes that employee household location will respond to changes in transport costs, so that any transport problem areas are addressed in LASER by changes in mode or employee household location to minimise passing through these problem areas in the journey to work (subject to constraints in availability of appropriate housing types in other zones). This is why major land use changes can result in apparently minimal changes in road traffic. However, the number of changes in mode or employee household location to achieve an equilibrium situation may be a useful indicator of the degree of future transport problems.

For policy analysis, we believe LASER can compare different levels and locations of development at a strategic level to rank options against their long term impact on travel behaviour. We also believe that it is worth extending the representation of household location so that more factors are taken into account explicitly. But it should be remembered that in response to transport problems LASER is changing the zones from which employees are drawn for a particular employment location, and it is not clear that either the employment or housing markets are flexible enough to respond quickly to avoid transport problems from major developments. In comparing options, it is worth identifying the number of changes in mode and employee residential location since large changes (which may not be feasible in the short term) are
likely to highlight the need for transport infrastructure improvements.

7.3 Conclusions

- The major difference between LASER and conventional modelling is that LASER forecasts where people live in relation to employment location taking account of transport costs and the availability of suitable housing.
- It is not appropriate to use LASER as the sole means of determining the infrastructure required to accommodate new development.
- LASER can be used to assess options for major employment and housing location, taking account of transport situations on all available modes. It can also identify appropriate levels of new development to meet policy objectives.
- For development control purposes, LASER should be run with the assumption that all proposed dwellings are fully occupied, in order to determine the full extent of infrastructure requirements.
- LASER output represents an equilibrium position, and requires flexibility in the employment and housing markets to reach that equilibrium. In some cases, minimal changes to road traffic can be forecast at this equilibrium position despite some major land use changes, but this may be as a result of major changes in commuting journey patterns over a wide area and these changes may take time to occur.

A useful indicator of how long it may take for this equilibrium to occur (or how difficult it may be to reach this equilibrium) would be a measure of the number of journeys to work which need to change to achieve the LASER forecast. A large number of changes may suggest that there are significant transport problems which should be addressed rather than relying on the housing and employment markets to minimise the need for new infrastructure.

Appendix A: Review of LASER by RAND Europe

RAND Europe

To: Mott Macdonald

From: Barry Zondag, RAND Europe

Subject: Review of Land use module of LASER

Date: 4 June 2004

Reference: 04065

This memo discusses the land-use modelling within the LASER model. The discussion is structured as four sections: residential location choice, firm location choice, general comments on the model and recommendations for development. The memo presents some empirical evidence found in the literature for the relationship between transport and the location choices of residents and firms. This empirical
evidence and insights from other Land-use and transport interaction (LUTI) models are used to discuss potential improvements of the LASER model. The general comment section addresses a few more fundamental issues. In the final section some alternative development paths are outlined. The most appropriate path depends on the expectations and requirements of the users of the LASER model.

A.1 Residential location choice

Background

The residential location choice is influenced by many different actors, such as government, land owners/speculators, households, etc. All these actors interact with each other in various markets, of which the key markets affecting residential land-use are:

- Land market
- Real estate market
- Housing market
- Labour market

These markets operate for different components of the system. The three components of the land-use system are:

- Land
- Objects
- Activities

Each component of the system has its own time dynamics. Land functions, for example urban land use, normally remain unchanged for very long periods of time, and can have time spans of centuries. Objects, offices and houses, also have a relatively long life as result of high sunk costs. The activities, firms and households, are the most flexible component. But also their flexibility is constrained by high transaction costs (financial as well as social) and they do not react immediately to changes in the system.

Modelling of residential location choice, under assumption of fixed supply of houses

The key question in LUTI-models is how strongly the location choice of residents is influenced by changes in the transport system. The description hereunder addresses a LUTI-model, like LASER, without a land market and where supply of houses for each zone is considered to be an exogenous input.

Factors influencing residential location preferences are:

- Demographic changes
- Distance between old and new location
- Household characteristics such as age of oldest person, household size, household income
- Dwelling characteristics, type of house, size, number of rooms, garden, tenure
- Price
- Neighbourhood characteristics
- Accessibility
An important question is what is the influence of each of the variables on residential location choice. Are transport changes for example a key driver of suburbanization? Or are other factors, such as demographic developments, local amenities or dwelling characteristics, more dominant factors? An analysis addressing the importance of accessibility in residential location choices needs to include all key explanatory variables explaining residential location choice.

The number of empirical studies of transport impacts on land-use are quite limited. Some reasons for the limited attention from empirical researchers may be the following:

- In developed nations current transport policies do not result in dramatic changes in accessibility and therefore in large changes in land-use.
- The time lag between a transport measure and land-use change is rather long. Land-use changes occur much more slowly than, for example, changes in transport behaviour. This time lag puts high demands on an empirical analysis with a need to collect data for a long time period (e.g. 10 to 20 years) and to adjust for all other relevant developments, which might influence land-use changes, in this period.

According to Miller et al. (1998) none of the empirical studies has succeeded in meeting these problems so far. Miller notes that in virtually no case the study design provided an adequately controlled ‘experiment’ to properly isolate the impacts of transport investments from other evolutionary factors at work in the urban region. Although the difficulties are clear and methodological questions remain, a number of studies are certainly worth mention.

Most of the empirical studies have limited their scope to transit developments; this is counter-intuitive with the expectation that larger land-use impact will result from road transport measures. Miller et al (1998) made an extensive review of studies of the impacts of transit projects in the US and Canada. The key observation is that land-use impacts of transit developments, if observed, tend to be small and concentrate around the stations. A study by Giuliano (1995) for the San Francisco area resulted in the conclusion that the impact on land-use of transit developments after 5 years of operation was insignificant.

Several research projects have focused on the relationship between transport and urban form, and more specifically on the trade off between housing type (residential densities) and accessibility. Hunt (2001) concludes, based on Stated preference research in Edmonton, that very dramatic improvements in travel times to work would be required to compensate the typical household for a move into higher density dwelling forms. A stated preference study for six cases in Belgium and the Netherlands by Molin and Timmermans (2002) confirms these findings. They concluded that regardless of the study area and the model specification, accessibility considerations are significantly less important than housing attributes and attributes related to the neighbourhood.

A study by Weisbrod (1978), based on revealed preference data, emphasizes that available transport policies marginal influence on residential preferences. Factors beyond the scope of public policy, such as the desire for single-family, detached homes among families with children, and reduced moving rates for older persons and families with several children, all affect mobility and location patterns more than other factors related to public expenditures. This study of Weisbrod also highlights the importance of housing costs in residential location decision. It is often suggested that transport policies have a strong impact on house prices. A study by Pagliara and Preston (2003) suggests that transport changes appear to have relatively modest impacts on house prices.
A study by RAND Europe (2003), estimating residential location choices based on a large housing market survey in the Netherlands, confirms the findings above and further highlights that residential mobility is a local/regional process. A large majority of the households move within their own municipality or region because of many factors such as imperfect information, social networks, etc.

In general it can be stated that accessibility seems to have a modest positive influence on residential location choice. This makes accessibility one of the explanatory variables for residential location choice. However demographic developments, neighbourhood amenities and especially housing attributes seem to be more dominant explanatory variables. It is therefore important that in a LUTI-model all key variables are included to have a right representation of the role of accessibility in residential location choices.

**Discussion of LASER**

The bullet-points hereunder summarize very briefly the current modelling of residential location choices in LASER. For a more detailed description, refer to the LASER enhancement project documentation. LASER divides the population in employed and unemployed households:

- Unemployed households, exogenously allocated to zones
- Employed household, location choice is based on a combination of:
  - commuting times and costs;
  - a constant zonal attractor per household type;
  - dwelling prices, responsive to local supply/demand situation;
  - one type of floorspace.
- Housing supply by zone is a scenario input.

The LASER model consists of an incremental model, addressing supply side changes in the housing market and an equilibrium model addressing the housing and labour market. In this equilibrium model all households (with employed members) can potentially move and resettle. A limitation of this approach is that it studies only the static location patterns of all households, regardless of when they have last moved. In reality only recent movers may be in some form of equilibrium with respect to their tradeoffs of dwelling attributes, neighbourhood attributes and accessibility. Within the family of LUTI-models there are emerging a number of incremental models such as DELTA (DSC), URBANSIM (University of Washington), IRPUD (University of Dortmund) and TIGRIS (TRC Netherlands, RAND Europe). In these models households do not make instantaneous adjustments to changing conditions. In the LASER model there is potentially only a time lag in the response for changes in accessibility but not for other features. The incremental models seem to have more strength in explaining how the urban system progresses in time and what the main drivers are. An important trade-off in considering these incremental models is that these models are normally less well founded in economic theory.

In the LASER model the zonal attractor is household type specific for each zone and constant for future years. This is of course a very strong simplification of underlying processes and makes the model incapable of responding to changes in key explanatory variables for residential location choice such as changes in the local environment, changes in social-economic conditions (e.g. average income) in a neighbourhood, local services, etc. Another important limitation is that only one type of residential floor space is incorporated in the model: it would be a significant improvement to extend the model to include more dwelling types. Our recommendation is to enrich the modelling with more specific explanatory variables addressing neighbourhood amenities instead of one very aggregated zonal attractor. In this way
the model will become responsive to changes within the zones. Another recommendation is that the model will benefit substantially from more detail in dwelling types. Residential location decisions are strongly influenced by dwelling types and even a very rough segmentation (two or three types) means a significant improvement of the modelling. Household segmentation and dwelling segmentation needs to be adjusted to each other, because it is mainly household characteristics, like having children or not, that explains a preference for a certain dwelling type.

Endogenous inclusion of the location choice of all households including unemployed households, especially the emerging group of active elderly, makes the model more responsive to demographic changes. Another point is that the line between employed and unemployed person/households is not fixed. It should be noted that their status could change with economic cycles and demographic developments. In the LASER model employment is only influenced by demand factors in the labour market and developments on the supply side such as demographic changes are not included.

An alternative approach to model the housing market in LASER is a two-step approach, following a move/stay choice by residential location choice. This approach has been successfully followed in other LUTI models like URBANSIM (USA), IRPUD (Germany) and TIGRIS (Netherlands). The incremental models seem to be more realistic in considering the dynamics of the urban system and absence of equilibrium in the housing market for all households at one point in time. The incremental models are also more capable of addressing the various time lags in the system. Another point is that household’s old location is an important explanatory variable in the residential location choice module. Certainly if the study area is as large as the Southeast region of the UK the spatial pattern of household movements becomes important. In general household movements are mainly made in the surrounding the old house, due to factors such as better information about opportunities or social networks. It seems important to incorporate this behavioural feature within LASER.

We conclude that the above suggestions would result in a more realistic modelling of the number of household movements and location choices. The key improvement is that the model would capture the most important reasons for households to choose a location in a better way by incorporating local demographic processes, the distance of household movements, neighbourhood amenities and dwelling options. Furthermore a more dynamic structure of the model would enable the modelling of time lags in responses.

**Unfixed housing supply, modelling of the land market**

The description above was based on a fixed exogenous housing supply for each zone. In reality the housing supply for each location reacts to housing demand, areas with a high demand for houses normally grow faster than originally planned and areas with a low demand for houses grow slower than originally planned. Government polices and regulations play an important role in these supply and demand interactions. The methods used in existing models in this field (e.g. URBANSIM, TIGRIS) are often context specific in line with the specific role of the government in a study region. In the US these models quite often follow free market principles and project developers are the key actors. A piece of land (e.g. agricultural land) will transfer into a residential location if demand is available and the housing price is higher than the sum of land and construction costs. In continental Europe the government normally has a stronger influence on the land market. In the models this situation is reflected in the attention to zoning policies and other regulations. Household construction, initiated by demand, can only occur at certain locations under certain conditions.
Models with an endogenous treatment of the number and location of houses are in principle more responsive to changes in transport costs and times than models with exogenous housing supply. Preferably a land market would be incorporated within the LASER model. In principle the MEPLAN software facilitates the modelling of the land market. It is possible to represent land and floorspace directly in the modelling and a bidding for space process can be used to calculate rent values and consumption of floorspace.

The complex role of different tiers of government on the spatial zoning and regulation makes it normally necessary to work with alternative scenarios for the influence of the government in this type of model.

A.2 Firm location choice

Relationship firm location and accessibility

Although it is hard to describe the importance of accessibility in the location choices of firms, because of the large differences between economic sectors and the many factors influencing the location of businesses, in general it can be stated that accessibility has a measurable positive influence on the location choices of firms. Empirical research shows that businesses are, controlling for other factors, especially sensitive to accessibility to freeways. Kawamura (2001) and Bok (2003) show empirical evidence that over time businesses have moved closer to the freeway ramps. A stated preference study by Leitham (1999) concludes that the importance of road links to location choice varied considerably between groups of firms. For national and local relocations access to road links is in most cases important and for foreign inward investors it is unimportant. Along the observed orientation to freeways a suburbanization pattern is observed by Kawamura (2001) and Shukla (1991).

The largely significant and positive findings for freeway access in the location choice of firms cannot be confirmed for transit infrastructure. Transit seems to have at highest a marginal impact on the location choices of firms, if all firms are included. However for specific sectors such as public services transit accessibility can be an important variable. Another exception can be made for locations with a very high market share for public transport, like in the central areas of a large metropolis.

The above findings illustrate that it is important to model, if possible, firm location choices endogenously. Significant changes can be expected in the location pattern of firms as a long-term response to changes in the infrastructure. In land-use and transport interaction models the focus is on regional and local resettlements of firms. However most resettlements occur at this regional/local level due to the strong relationship of a firm with its location. Important factors explaining this relationship are the accessibility of existing employees, providers and clients, and better information about local opportunities for office space or industrial sites.

In the LASER model the location choice of the large majority of economic sectors are modelled exogenously, only local retail and education services are modelled endogenously. It is clear that the LASER model will benefit from a more endogenous modelling of location choices of firms. The first and most radical option to improve the model is to take advantage of the input-output framework within the MEPLAN software and to use the strength of this framework in addressing the various relationships of businesses. This framework is well tested and has been used before for simulating industry location dynamics. For example, a MEPLAN application for the Sacramento region in the US shows that the movements of industry are substantial, and are much larger than the movements of households (Abraham
and Hunt, 1999). A rather weak point in the MEPLAN modelling is the important role of zone specific constants. These constants allow existing patterns that occur for reasons not endogenous to the model to be carried through to the future. It seems that too many important explanatory variables are easily included in this exogenous zonal attractor. Inclusion of more specific explanatory variables would seem to be a significant improvement.

**Alternative options:**

If, for example as the result of data limitations or methodological preferences, it is not possible to operate the input-output framework for the London and southeast region then alternative modelling options are available. Two modelling approaches, operational in existing Land-use and transport interaction models, are presented hereunder. The explanatory variables of the model are also included to present alternatives for the rather aggregated zonal attractors normally used in MEPLAN. Alternative modelling approaches are:

- A so-called explanatory shift/share approach. Such an approach combines structural changes in the economy at the national/regional level and location factors to explain local differences in development. This approach has been applied, for example, in the OPERA labour market and TIGRIS LUTI model in the Netherlands. The approach uses elements from various economic theories and is especially strongly driven by empirical results. A time series data set of employment by sector at a local level is needed to estimate the model. The model operates incrementally and to avoid a strong influence of specific economic upturns or downturns a relatively large time series is needed, preferably a time period in line with the forecasting period. In the TIGRIS model the following explanatory variables are included:

  **Transport variables**

  Accessibility for employees

  Accessibility for freight

  Accessibility for business

  European accessibility

  **Regional/local factors**

  Changes in population

  Agglomeration variable

  Urbanization variable

  Relative share of a sector in a region

- Employment mobility and location model (URBANSIM, University of Washington 2000). The employment mobility model in URBANSIM predicts the probability that jobs of each type will move from their current location during a particular year. The employment location choice model predicts
the probability that a job that is either new, or has moved within the region, will be located at a particular site. The model structures can be adjusted to specific application data availability and policy questions. If longitudinal data on employment is not available at a spatially disaggregated level then it is possible to use only the employment location choice model. All additions to employment can be managed by this module. On the other side, if data allows, it is possible to estimate a nested model, such a structure the relative attractiveness of commercial space in other locations influences mobility choice. Calibration of the Urbansim model, for example for the Eugene-Springfield region in Oregon, is based on a geocoded establishment file. A sample of geocoded jobs in each sector is used to estimate the coefficients of the location choice model. The independent variables used in the employment location choice model are:

**Real estate characteristics**

Prices

Development type (land use mix, density)

**Regional accessibility**

Access to population

Travel time to CBD, airport

**Urban design-scale**

Proximity to highways, and arterials

**Local agglomeration economies within & between sectors: centre information**

All methods, currently operational within LUTI-models operate, to my knowledge, at the level of jobs as the best proxy for firm behaviour.

### A.3. General comments on LASER

This section addresses some general issues in the LASER modelling framework. It is recognized that some of the suggestions include quite radical changes to the existing framework. If these types of structural changes are to be considered, a deeper study is needed to analyse the costs and benefits of the changes.

#### Dynamics

The LASER model uses one very large time step (one step up to 2016). A more dynamic framework could include responses for housing supply and office supply, for example responses to market situations such as housing vacancy and demand/supply ratios of the previous time step. Most of these responses, such as price adjustments and construction or demolition of houses, are not instantaneous but occur with a certain time lag. A model with smaller, e.g. yearly, time increments is more capable of addressing these processes. An alternative is to disentangle some of the elements that make up the LASER model, with a view to bringing in more scope for explicit calibration on changes over time.
Hierarchical structure - link employment and residential location.

In the LASER model local changes in employment of almost all economic sectors are exogenous inputs. The settlement pattern of the economically active population in a region is in this context mainly driven by the exogenous development pattern of the economic sectors. There are several reasons to relax these assumptions in the modelling.

- Accessibility is normally a more dominant explanatory variable in the location choice of firms than it is in the location choice of residents.
- The settlement pattern of residents does not only influence local retail and education services (this is currently the case in LASER). The settlement pattern of many other economic sectors are potentially influenced by changes in the settlement pattern of residents, examples are government and other public services, manufacturing, etc.
- In reality the number of economically active persons is not so flexible that it is influenced only by developments in the economy. The number of economically active persons is influenced by demographic changes, domestic migration into and from the study region and international migration.

The suggestion is to relax existing hierarchical relationships in the modelling and to use existing data to empirically estimate the effect of work on location choices of residents and the effect of population on the location choices of firms. It is important that the coefficients of these variables are estimated together with all the other relevant variables.

Modular set-up and calibration

Most of the suggestions in this memo call for a more flexible framework in which it is possible to calibrate specific modules based on available data sets. Currently the three main model components, input-output spatial choice and zonal constraints are so closely intertwined that they are solved simultaneously. This integrated framework has of course the charm that everything affects everything. But the trade-off is that it results in practical limitations. It seems that the very restrictive number of explanatory variables to explain processes such as residential or firm location choice and the unbalanced emphasizes on flows/interactions instead of objects/land are negative consequences of the chosen framework.

A.4. Recommendations

The way forward depends greatly on what type of studies or policy questions the LASER model is going to be used for. Three options are described hereunder ranging from a traditional transport model to a full urban/regional land-use and transport interaction model.

5. LASER is going to be used to evaluate transport policies as in traditional transport evaluations. Scenarios are used with exogenous social-economic projections by zone. In this case LASER is used as a traditional transport model and improvements in the land-use modules are not necessary.
6. In this option land-use (number of houses, office space, industrial sites) is exogenous in LASER but the social-economic projections by zone are endogenous. A transport measure, in this case, results in changes in the social-economic characteristics of zones and these changes have an additional effect on the outcome indicators. In a market with supply shortages, like the housing market, the difference
is not so much in the overall number of households in a zone but the main difference is in the number of households by segments for a zone. This option can be considered as a partial integrated land-use and transport interaction system.

The current LASER model is only partly fulfilling this task. Recommendations to improve LASER for option two are the following.

- Improve residential location choice modelling by including more key explanatory variables as various such as dwelling types, neighbourhood amenities and local demographic processes. It seems that it should be possible to realize these improvements within the current framework. For an endogenous modelling of move/stay decisions and spatial behaviour of households making a move it is necessary to make more structural changes in the model.

- Include firm (job) location choice endogenously in the modelling. This has been realized in other MEPLAN applications for other regions. If it is not possible to realize this type of modelling (input-output) for the Southeast region it may be worthwhile to explore the opportunities for alternative modelling options as described in this memo.

7. This option can be referred to as a fully integrated land-use and transport model. In this option land-use is also an endogenous part of the modelling and the model needs to include a land market. The result is that land-use changes are responsive to changes in the transport system. A change in the transport system can result in a different distribution of jobs and residents within the Southeast. It is questionable, considering relatively large regional migration rates in the UK if the total numbers for the region should be kept fixed. This option captures the urban system in the most comprehensive way and is therefore well able to simulate urban/regional dynamics. One of the outcomes of this approach is long term changes in transport demand as a result of changes in the spatial structure. For example, transport demand on new highways is not only the result of changes in mode/destination/route choice of the original population but also there is an additional growth resulting from changes in the spatial pattern. The size of this type of additional transport effect depends of course on the size of the coefficients for accessibility in the residential and firm location choice modules.

- a. The current LASER model is quite far away from this situation. The improvements described under option 2 need to be realized also under this option and additional developments are needed to model housing and commercial space supply and demand interactions. A priority is that the model becomes more dynamic to use supply/demand information to adjust construction and demolition rates. This can be modelled either by government and/or project developer responses to changes in the location preferences of the residents and firms. In principle it is possible to realize this stage within the MEPLAN framework. Disadvantages of the framework are the complex calibration of integrated framework, that supply side modelling is not strongly developed and in general the applications are not very dynamic (5 year time steps). A strong point of the MEPLAN framework is its foundation in urban economic theory and its ability to represent the bidding process for land and trade-offs between land costs, supply costs and transportation. If such a radical improvement of the LASER model is considered it might be worthwhile to study the advantages and disadvantages of the MEPLAN framework and alternative modelling approaches in more detail.
A.5 References


De Bok M., B. Blijie and F.M. Sanders (2003), *The influence of the transportation system on land-use: a disaggregated analysis of the migration patterns of firms on the office market and the accessibility of locations*, paper presented at the 30th Colloquium Vervoerplanologisch Speurwerk, Antwerp


RAND Europe, BureauLouter, Spiekermann & Wegener (2003), *Functioneel ontwerp prototype TIGRIS XL*, prepared for the Transportation Research Centre of the Netherlands Ministry of Transport, Public Works and Water Management


Please note that in land-use and transport interaction models the term land-use refers also to interactions between activities.

Appendix B: Comments from WSP Policy & Research

This Appendix contains comments received from WSP on Chapter 5 and Appendix B.
Comments on Chapter 5 (Consultation with LASER customers)

WSP would like to clarify a number of issues associated with the responses. To help the reader, the consultation response is first presented in quotation marks and underlined, which is then followed by comments from WSP.

- 'Validation is poor. This may be due to the relatively detailed network but coarse zoning system, leading to a large number of intra-zonal trips, which are not assigned.'

[WSP comments]: Would it be correct to assume that the comment 'Validation is poor' refers to the fact that the comparison of LASER road link loads does not achieve the DMRB standards set for road traffic models? The link load validation is affected by the relatively large zone size, and lack of resources in refining road traffic assignment at the time of model calibration. Note that all other key aspects of model validation have achieved a good standard, as shown in this report. As for intra-zonal trips, unlike conventional transport models, LASER contains passenger travel in all distance ranges (including short trips under 1 mile in length) in order to model transparently both journey lengthening (when travel conditions improve) and journey shortening (when congestion worsens or travel costs rise). In many road traffic assignment models, the proportion of intra-zonal and other short trips is small because they are often absent from the observed base year matrix.

- 'Lots of LASER results are counter-intuitive, e.g. extra houses in Thames Gateway do not increase traffic on the M25. One user commented that counter-intuitive results could usually be understood if thought through and discussed with WSP. Another user was more sceptical'

[WSP comments]: The issue of additional housing and traffic levels has been clarified by Chapter 3 of this report. WSP would be happy to discuss any other doubts or queries on the model results.

- 'LASER seems to model people living closer to their work than is the case in reality. This results in overestimation of the use of non-mechanised modes and PT.'

[WSP comments]: It is important to clarify which part of the model results has led to this perception. The first bullet point under 2.5.1 of this report says comparison of modelled trip length distribution by demand segment with NTS is generally good for commuting. Also see 2.5.2(i), which says modal split for commuting is also generally good. The distribution and modal split for education and non-private trips do not fit well with the observed data, but they account for a very small proportion of car kilometers on the trunk network during AM peak. White-collar business travel was refine-tuned during the Thames Gateway study and now fits much better than at the time of model validation in 2002.

- 'It can be difficult to establish what the model does and how it does it - WSP do themselves no favours here.'

[WSP comments]: WSP have been transparent with the model inputs, assumptions, model calibration and test results in all recent LASER applications, and all such queries have been clarified fully. All key components including the mathematical equations and main input data are available from existing documentation. There are standard tables and figures for presenting model results since the Thames Gateway Study, which help to compare results across model runs. However, WSP accept that a full technical manual, which spells out all model implementation details in one place, would be beneficial to the user. Owing to the limit of project resources it has not yet been possible to produce such a
Comments on Appendix A (Review of LASER by Rand Europe)

WSP agree with RAND’s general recommendations quoted in Chapter 6. The recommendations were similar to those already identified in a study carried out for DfT, ’The Cost-effectiveness of LASER Modelling Options’ in 1999.

However, WSP have a number of concerns and queries on the technical details of the Rand review. For example, it is not always clear how some of the statements are supported by empirical evidence. However, it is assumed that these details are not relevant for this report. Should the technical details become relevant in a future date, WSP would wish to make further comments.