TESTING THE LAND-USE/ECONOMIC IMPACTS OF TRANSPORT SCENARIOS USING TELMOS

David Simmonds[*], Scott Leitham[♦], Andy Dobson[*] and James Nicoll[*]
*David Simmonds Consultancy, Suite 14 Millers Yard, Mill Lane, Cambridge, UK
♦ MVA Consultancy, Stewart House, Thistle Street, North West Lane, Edinburgh, UK

Paper presented to the World Conference on Transport Research, Berkeley, California, June 2007.

1 INTRODUCTION

1.01 This paper describes the land-use/transportation interaction model, TELMoS[1] and the ways in which it can be used to test both the economic and land use implications of transport interventions and the implications for transport networks of major land-use developments.

1.02 The model was developed by DSC and MVA for the Scottish Executive. Its coverage extends to include around 95% of the country's population and most of the local authority areas within mainland Scotland. In this paper we firstly describe the modelling approach that has been applied and the way in which the model has evolved over time. Then, in two separate sections, we describe the application of the model to examine the impact of re-opening the Airdrie - Bathgate rail link and the effects on traffic and congestion levels across Edinburgh of a scenario of major office development to the West of that city.

1.03 In the final section we consider areas of further research and the ways in which the model might be developed to better model and inform the land use planning process.

2 MODELLING APPROACH AND BACKGROUND

2.01 The modelling approach makes use of the TMfS/TELMoS land-use/transport interaction modelling system which has been developed for the Scottish Executive over the past two years.

2.02 TMfS is a transport modelling system developed by MVA as a major extension and enhancement of the earlier Central Scotland Transport Models.

2.03 TELMoS extends TMfS into a land-use/transport interaction model by linking TMfS to an application of DSC's DELTA land-use/economic modelling package[2]. This application has been developed jointly by DSC and MVA.

2.04 Full documentation of the TMfS and TELMoS systems has been prepared for the Executive. The following paragraphs provide a brief outline of how the model works.

---

[1] TELMoS is an acronym standing for Transport, Economic and Land Use Model of Scotland.
[2] Details on the general design of the DELTA modelling system can be found in Simmonds (1999) and Simmonds and Feldman (2005)

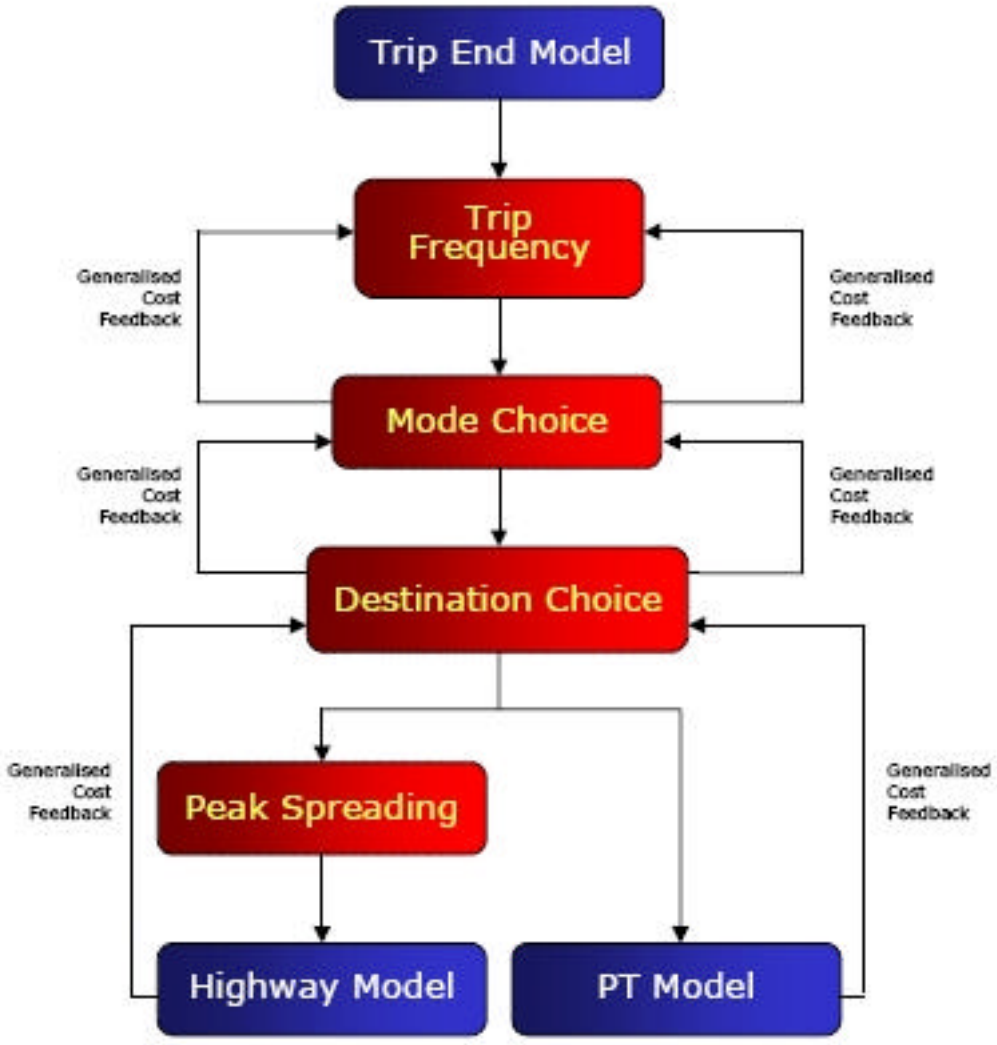
The Transport model

2.05 The TMfS (Transport Model for Scotland) model is a multi-modal demand and assignment model covering 95% of Scotland's population.

2.06 TMfS was developed using the Citilabs CUBE software suite, incorporating TRIPS 3 and now TRIPS Voyager. It uses over 1000 zones to represent all of Scotland with the exception of Inverness and the Highlands; Glasgow, Edinburgh and the Central Belt are modelled in particular detail.

2.07 Alongside the spatial dimension, TMfS includes the following choice dimensions, Macro time of day choice (3), personal and freight trip purposes (5), personal modes and freight types (3 and 2) for users disaggregated by car ownership (2). Further features include feedback from costs to overall trip frequencies and the modelling of peak spreading in the AM peak.

2.08 The simple outline of the model is shown below.



2.09 The highway and public transport networks are based on the original 1997 network from CSTM3, updated both with more recent data from modelling work in Glasgow, the Clyde Valley and Edinburgh and with information from the relevant local authorities elsewhere.

2.10 Survey and count data for public transport and highway usage is again a combination of previously available data, data from more local modelling projects and data from work commissioned specifically for TMfS

2.11 The transport model is used in the conventional manner, that is, it forecasts the pattern of travel expected on an average working day of a chosen year. The years represented in the application of TELMoS described in this paper are 2001, 2006, 2011 and 2021. The operation of TMfS within TELMoS is almost exactly the same as when it is used alone. The key difference when it is used in a land-use/transport interaction model is that the land-use and economic data driving the demands for transport come from the land-use/economic model rather than being prepared "manually".

2.12 The transport model is run, as already mentioned, in 2006 and 2011, with the possibility of a final run at 2021.

The Land-Use model

2.13 The DELTA Land-Use Model of Scotland can be considered as containing the following three linked sub-models:

- Regional Economic Model
- Migration Model
- Urban Model

The first two of these interact directly with the fourth component of the land use/transport interaction model, namely the transport model. These components and the general linkages between them are shown in Figure 1, and described within the following paragraphs.

2.14 The **transport model** (TMfS) is described above. It estimates the costs and times of travel between each pair of zones, allowing for the congestion caused by the forecast traffic.

2.15 The money costs, times and other inconveniences for each type of motorised travel are summarised as generalised costs, which provide a single variable describing how difficult it is to travel between any pair of zones for a particular purpose during a particular period of the working day. Generalised costs for walking have also been estimated. These generalised costs are passed from the transport model to the economic and urban models.

2.16 In years for which the transport model is not run, generalised costs are assumed to remain unchanged from the preceding "transport model year". For example, the generalised costs for 2011 are used for the whole of the following decade. (This approximation is due to the time taken to run the transport model; it is impractical to apply it more frequently.)

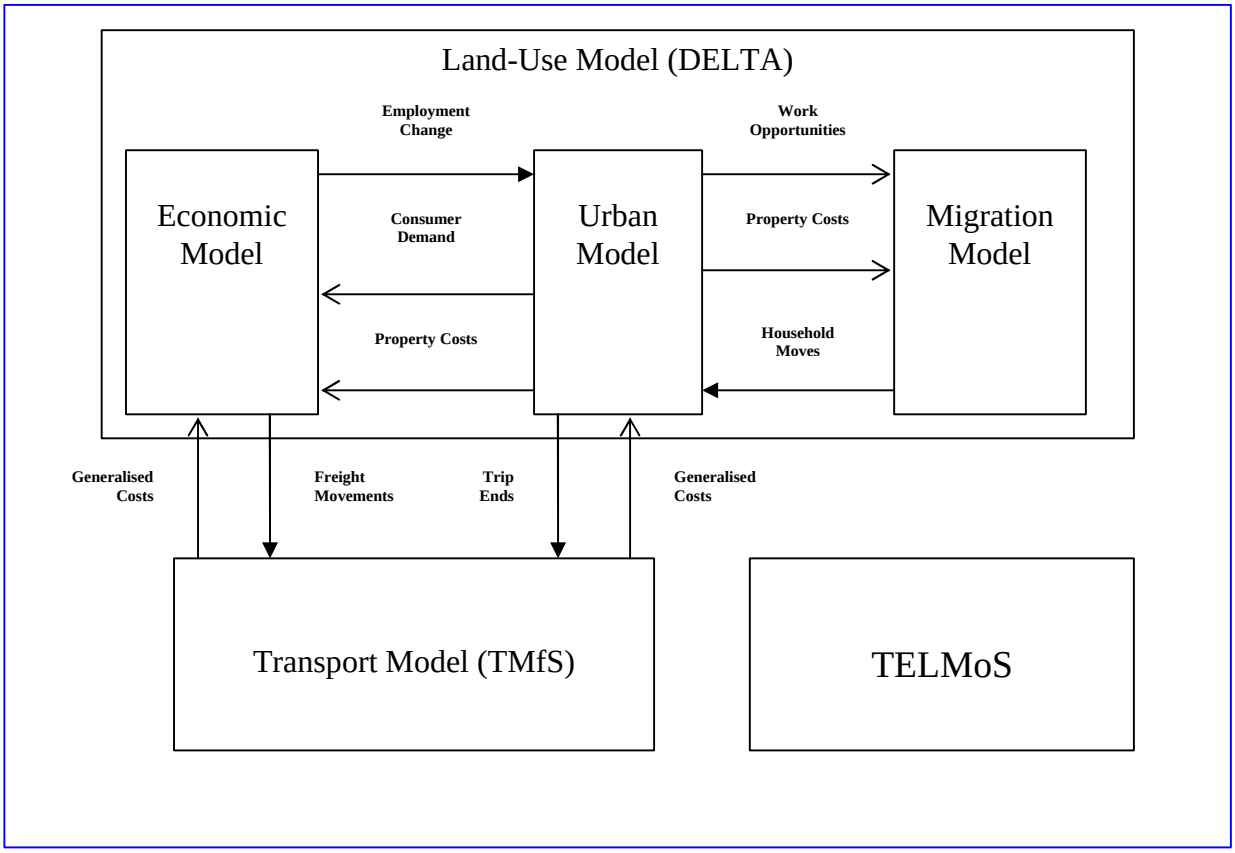


Figure 1 TELMoS: Main model components and linkages

2.17 The **economic model** forecasts the growth (or decline) of different sectors of the economy in different sub-regions of Scotland.

2.18 The economic model operates at a regional level (Simmonds and Skinner, 2004), it takes a number of inputs, including forecasts of growth in the Scottish economy and official estimates of the linkages and input:output ratios, (technical co-efficients) between different sectors of the Scottish economy (Scottish Economic Statistics, 2003). The model is concerned with the distribution of this economic activity **within** Scotland. The linkages which affect this distribution are shown in the diagram: these are

- generalised costs of transport, already mentioned:
- consumers' demands for goods and services, from the urban model; and
- property costs of employment location (rents), likewise from the urban model.

All of these may be directly or indirectly affected by transport changes such as road or railway schemes.

2.19 Within the economic model, two distinct processes are represented, **trade** and **investment**. The first deals with

- where goods and services are produced within Scotland, and hence the location of production related employment
- where they are consumed, and

- the resulting trades in goods and services between different parts of Scotland, and to the rest of the world.

2.20 These variables respond quickly to changes in the transport system and are modelled using a spatial Input-Output model calibrated using data from UK and Scottish sources.

2.21 The second, slower, process uses the resulting production costs and relevant accessibilities to generate the pattern of investment across the sub-regions of Scotland, using an incremental logit model.

2.22 Because the location modelling only applies to new investment, industrial capacity and related employment only gradually respond to changes in the transport system. Both processes will tend to increase investment and production in areas of Scotland which have improving access both internally and to other parts of Scotland. Within the model, these increases will be at the expense of other parts of the country.

2.23 The key outputs of the economic model are changes in employment by sector and sub-region, and these are passed to the urban model. Data on the demands for freight transport are also passed to the transport model in the appropriate years.

2.24 The **urban model** deals with the location of households and jobs by zone within each area, the matching of the supply and demand of labour and with the processes of development which provide the additional floorspace in which households and jobs can be accommodated. The location of households at this level is strongly influenced by the availability of housing, new and second-hand; likewise the location of jobs is strongly influenced by the availability of appropriate types of commercial floorspace. New floorspace supply is in turn restricted by planning policies. The locations of households and jobs within the stock of buildings are influenced to some extent by the accessibility of each zone. Different measures of accessibility are calculated using the generalised costs output from the transport model. These measures act as influences on different activities: for example, households are influenced by accessibility to workplaces and services, whilst businesses are influenced by accessibility for potential workers and customers. This is the key linkage through which transport affects the local pattern of location, and through which different transport schemes produce different forecasts. Note that many of these effects can involve different uses of a given stock of buildings, e.g. an increase in employment may involve an increase in the ratio of workers to floorspace within a zone rather than the provision of additional floorspace.

2.25 Given these and various other influences, the urban model calculates the location or relocation of households and jobs, which are critical inputs to the transport model.

2.26 The urban model also reconciles the supply and demand of labour as population and production change, resulting in changes to the employment status of different households.

2.27 It also estimates the rent values arising from the competition for different kinds of property in each zone. The resulting costs are passed both to the economic model, and to the migration model. The urban model also passes information on job opportunities to the migration model.

2.28 The fourth component of the DELTA package, the **migration model** forecasts the pattern of migration of households **between** the different sub-regions of Scotland. (Movements **within** sub-regions are forecast in the urban model.) The critical inputs which can vary as a result of different transport schemes are those from the urban model, i.e. job opportunities (the proportion of residents who are employed) and housing costs. Job opportunities are a strong incentive to migration. Housing costs are a weak disincentive.

2.29 There is no direct link from transport to migration: better transport does not in itself encourage migration (indeed, it may discourage migration if better transport allows increases in long-distance commuting). However, if better transport leads to employment growth, or allows better access to employment, that will tend to encourage migration into the area affected.

2.30 The overall land-use/transport interaction model therefore consists of these four components, with the economic, urban and migration models running in one-year steps and the transport model running at five or ten year intervals.

2.31 Multiplier effects, such as additional jobs generated by the expenditure of additional (attracted) population, are included within the model calculations. Because the model allows for spatial interactions between zones and between areas, multiplier effects do not necessarily arise in the same location as the direct effects that generate them.

2.32 Construction and operational employment resulting from transport investments are not forecast by the model and are not included in the impact figures discussed in the following section.

2.33 The land-use/economic model forecasts changes in one-year steps. It starts from a database derived from the 2001 Census and other sources, and runs forward to 2021.

3 USING TELMOS TO MEASURE THE ECONOMIC AND LAND USE IMPACTS OF A TRANSPORT SCENARIO – THE AIRDRIE –BATHGATE EXAMPLE

3.01 In this section we describe the use of TELMoS for assessing the likely impacts of re-opening the rail line from Airdrie to Bathgate.

3.02 This scenario involves the re-opening of the rail link between these two settlements after fifty years of closure. The ‘new’ line would have a number of transport-related benefits. In addition to providing public transport across the Airdire-Bathgate ‘gap’ it would result in enhanced rail services for several areas that are already served by the railway. Most noticeable of these would be the areas to the east of Glasgow (on the existing line to Airdrie) which would now be served by a regular service to Edinburgh and the area, to the east of the re-opened line, between Bathgate and Edinburgh, which would have a more frequent service. Other benefits, in terms of reduced congestion on the road network within the vicinity of the rail line and on some routes between Glasgow and Edinburgh, may result from a transfer of journeys from car to rail.

3.03 The land-use impacts of a transport scheme (such as this Bathgate-Airdrie reopening) are tested by running the model twice, with and without the scheme in question. The impacts are then identified as the differences in the results. The without-scheme case is usually referred to as the Reference Case.

3.04 In the present case the line is assumed for modelling purposes to reopen in 2011, this being the most appropriate of the years for which the transport model can be run. The with-scheme test is therefore a run of the land-use/economic model (DELTA) which differs from the Reference Case only in receiving transport model outputs which reflect the immediate transport impacts of the scheme in 2011. These impacts reflect the re-opening of the line and the improved level of service that was described above.

3.05 Note that in order to focus strictly on the consequences of the transport scheme itself, the Reference Case and scheme tests use the same assumptions about the levels of development that will be permitted in each zone.

Results

3.06 As we would expect for a rail scheme between two city regions which are already reasonably well linked by other public transport routes as well as by private transport, the impacts are most marked at local levels around the stations where the frequency and/or range of service will be most markedly improved.

3.07 The maps in Appendix One show that the scheme has positive impacts on groups of zones along the line in terms of both employment and population. All these maps show the differences between the with-reopening case and the Reference Case as forecast for 2021, i.e. 10 years after the modelled reopening date. The maps for absolute changes, maps one and two, both use coloured "pies" to show where increases are forecast, and grey "pies" to show decreases; the size of the pie is proportional to the impact. For both employment and population the major positive effects are around Bathgate, around Airdrie and along the route into Glasgow from Airdrie, with very little absolute effect between the two towns. In general these are small percentage changes, as shown in maps three and four.

3.08 These detailed maps show that positive impacts are generally occurring in the expected locations, but - because of the number of zones to consider, especially in the Airdrie area - they do not make it easy to see the overall effects. Figure 3.1 to 3.4 have therefore been prepared to summarise these impacts for corridors within West Lothian (to the east of the rail re-opening) and within North Lanarkshire (to the west of the rail re-opening).

3.09 In West Lothian three corridors are considered; the Bathgate corridor which extends along the line of the existing railway from Bathgate to Edinburgh, the Livingston Corridor to the south and the Linlithgow corridor, along the M9, to the north. The Bathgate corridor gains about 2000 residents and about 900 jobs by 2021; the Livingston corridor shows marginal gains and the Linlithgow corridor marginal losses.

3.10 To the western side of the rail re-opening, three corridors stretching out from Glasgow City centre were considered. These are the Airdrie corridor, between the centre and Airdrie, the Motherwell corridor, along the M74, to the south, and the Cumbernauld corridor along the M80 and A80, to the north. The

Airdrie corridor gains about 1800 residents and just over 600 jobs, with both the Cumbernauld and Motherwell corridors showing slight losses.

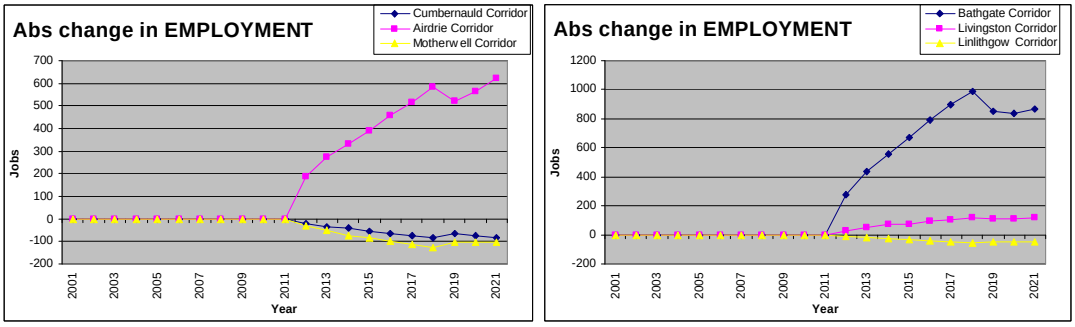


Figure 3.1: Absolute Change in Employment, West Lothian Corridors

Figure 2.2: Absolute Change in Employment, North Lanarkshire Corridors

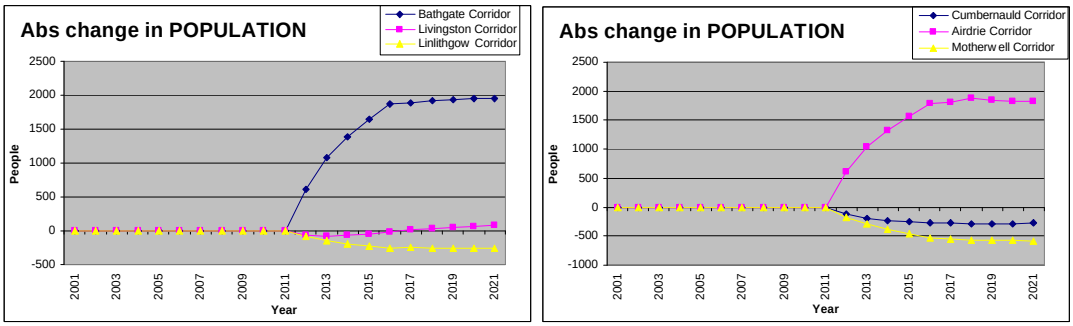


Figure 3.3: Absolute Change in Population, West Lothian Corridors

Figure 3.4: Absolute Change in Population, North Lanarkshire Corridors

3.11 The graphs also emphasise how the impacts build up over time. With the resident population, most of the impact occurs during the first five years, with relatively little change thereafter. Employment impacts are generally spread out over the whole of the decade following the reopening. Although we have not modelled the years after 2021, we would not expect significant further employment impacts beyond that date. These longer employment responses are a result of two separate factors. Firstly employers typically have longer response time to change, compared to households, and secondly some of the employment change is itself in response to the population change and is therefore in gradual response to the growth of population which itself is spread over approximately five years. (The employment impacts show a kink in the trend around 2019. This is a recurring feature of DELTA employment results due to the way in which the various timelags work through the model. It should probably not be there, but its presence does not significantly distort the pattern of the results. It may mean that the 2021 impacts are slightly understated, but not so much so as to affect any conclusions which might be drawn from the work.)

3.12 In all these cases it should be kept in mind that "losses" or "gains" are relative to the Reference Case and not necessarily absolute increases or decreases over time.

3.13 The district total impacts, shown below in Figure 3.5 and 3.6 confirm that West Lothian and North Lanarkshire both have net gains in population and employment as a result of the scheme. Given that the model is designed to distribute a fixed total of population and employment within Scotland, these gains are (within the model) necessarily at the expense of other parts of the country.

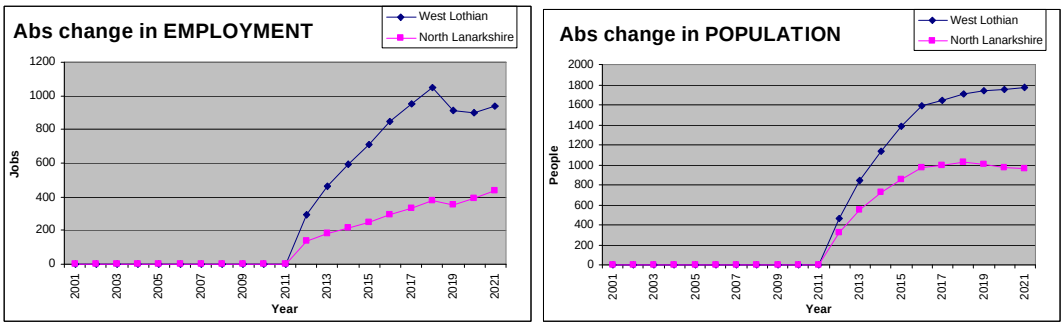


Figure 3.5: Absolute Change in Employment, West Lothian and North Lanarkshire

Figure 3.6: Absolute Change in Population, West Lothian and North Lanarkshire

4 USING TELMOS TO MEASURE THE TRANSPORT IMPACTS OF A MAJOR LAND USE DEVELOPMENT – THE WEST EDINBURGH EXAMPLE

4.01 In this second example we consider the transport effects of major new land use developments. In this instance the focus is to the west of Edinburgh. This is an area that currently experiences severe peak hour congestion. In part this is due to increased passenger numbers passing through Edinburgh airport and the recent opening of a new office complex which houses the headquarters of the Royal Bank of Scotland. As we describe below, the scenario to be tested involved the development of additional office space within this area; the purpose being to test the implications on the existing transport infrastructure (and also to evaluate the effect of various different remedial transportation meas.

4.02 With this example, a bespoke version of TELMoS was used. This had the following adjustments:

- Hermiston zone, which contained the airport, the recently opened Royal Bank of Scotland (RBS) and some other developments was sub-divided into three zones: this allowed the airport and the RBS site to be treated as zones in their own right;
- revisions to the standard TELMoS reference case that was used in the Airdrie-Bathgate example to reflect both the opening of the office development in 2005 (with over 3000 jobs) and the additional activity that is forecast to occur at the Airport. Latest forecasts of passenger numbers passing through the airport indicate that the volume will

increase from 6 million trips in 2001 to 17.8 million in 2021. It was assumed that the increase in employment would reflect this growth in activity;

- a base year of 2002 as opposed to the 2001 used in the Airdrie-Bathgate example;
- more detailed airport surface access modelling to reflect independent forecasts of trip generation at the airport.

4.03 The scenario to be tested assumed that two additional strategic headquarters would be built within the study area. The first of these, would be located, beside the current (2005) office development and would be open in 2011. The second would be to the west of this, on a site currently owned by the Royal Highland Showground. This would be opened in 2021.

4.04 Four measures were used to test the transport impacts of this scenario. These were:

- Congestion: this was measured in terms of vehicle hours 'lost' to congestion, within different geographical areas, relative to the 'reference case'
- Traffic: the volume of vehicle-kilometres travelled, within different geographical sectors, relative to the reference case
- Flows on key links: combined direction AM and PM peak hour flows at selected locations on the west Edinburgh road network
- Emissions: local air quality and greenhouse gas emissions within different geographical sectors

4.05 Where the transport measures were determined for geographical sectors, a five sector division of Edinburgh was adopted. This included a West Edinburgh zone, which covered the area to the west of the city and contained the airport and areas of development that were to be tested by the scenario; a Corstorphine Corridor, comprising the area to either side of the A8, Corstorphine Road. This corridor was to the immediate east of the study area and represented the main route between the airport and the City centre. To the south of the Corstorphine corridor we identified a corridor along the route of the A71; this represented the principle route from the M8 into the City Centre. The final two zones were the City Centre itself and the rest of Edinburgh.

Results

4.06 An analysis of the reference case shows that congestion is expected to increase five fold (when measured in terms of hours lost) within West Edinburgh. This is a greater increase than that forecast for either of the two corridors into the city centre or the city centre itself. However it is substantially lower than that forecast through the 'rest of Edinburgh' (see Table 4.2)

Year	West Edinburgh	Edin City Centre	Corstophine Corridor	A71 Corridor	Rest of Edinburgh	Total (includes Lothians and Fife
2002 Base Year	971	1287	895	534	2415	8758
2021 Hours	5181	2724	2005	1096	20974	43858

4-1- changes in congestion in the Reference Case (2002-2021)

4.07 This is due, in part, to the additional development that has previously described, at the airport, but also reflects other exogenous and permissive developments that are included within the reference case. The number and location of these developments is based on information obtained from the local planning authorities on sites that have been identified within the local plan or that have been granted planning permission.

4.08 The impact of the two additional office developments is shown in table 4.2. As one would expect, the largest increases (compared to the reference case) are within the West Edinburgh sector. However this application of the land use interactive model also demonstrates that the impact of development in one area can be felt over a much wider geographical area. Congestion grows by over 11% across all of Edinburgh and the surrounding parts of Lothian and Fife, with the one exception of the City Centre, where a relatively modest increase of 6% occurs. (In part this exception may be due to the higher levels of congestion that were already being experienced within the city centre in the base year).

Year	West Edinburgh	Edin City Centre	Corstophine Corridor	A71 Corridor	Rest of Edinburgh	Total (includes Lothians and Fife
2011	15%	2%	7%	14%	5%	6.4%
2021	32%	6%	19%	23%	11%	14%

4-2 **Percentage increase in congestion compared to reference case**

4.09 The rate of increase of traffic is less than that of congestion. Across most of the study area the rates of increase are in the range 2-4%. Even within West Edinburgh traffic levels only rise by 6.2% by 2021 (see Figure 4-3).

4.10 However a closer analysis of flows on key routes within and around the study area suggests that the two new office developments (contained within the test case) add significant traffic to the main strategic routes within the west of the city, namely the A90, M8, A8 and the Glasgow Road.

Year	West Edinburgh	Edin City Centre	Corstophine Corridor	A71 Corridor	Rest of Edinburgh	Total (includes Lothians and Fife
2011	3.2%	0.3%	0.7%	2.2%	1.2%	1.3%
2021	6.2%	0.7%	2.5%	3.3%	2.4%	2.7%

4-3 **Percentage increase in traffic flows compared to reference case**

4.11 Table 4.4 shows the increase in emissions that result from the increased traffic and congestion, within West Edinburgh. Similar information is available for the other sectors that were analysised above. This type of information is a salutary reminder that the environmental impacts of a land use development can be felt across a wide area and are not necessarily contained within the boundaries of the development site.

4.12 Further it enables local decision makers to judge the degree of carbon-dependency that would be associated with different spatial development options.

Year	CO (kg)	CO2 (kg)	HC (kg)	NOx (kg)	PM10 (Kg)
2011	18	1333	2	1	0
(%)	6%	2%	5%	0%	0%
2021	47	3600	5	4	0
(%)	15%	5%	10%	2%	0%

4-4 Change in Emissions within West Edinburgh sector

5 KEY AREAS FOR FURTHER RESEARCH AND DEVELOPMENT

5.01 The two examples have shown different ways in which an interactive land use and transportation model can provide an understanding of the impacts that a transport or land use development can have. These impacts are both spatial - in terms of the variation and spread of the impact – and temporal – with both short term and, as the various time-lags and delays in the development process, work through, long term impacts.

5.02 Despite the value that the current form of the model brings we believe that there is scope for further refinement in order to improve the way in which it both represents and can inform the planning system. These issues are considered below.

Modelling Retail and Office Development

5.03 Within the current version of TELMoS, additional floorspace is added as either exogenous or permissive development. The former typically represents those developments for which there is a certainty that they will go ahead (for

example developments that were under-construction in the base year), whilst permissive developments more often represents land that is expected to come forward through the planning process. Within the Scottish planning system, this would normally be land that has either been allocated within a development plan, say for residential or industrial development, or land (and development) that has been granted planning permission.

5.04 Please note, that the model does not assume that all of the permissive floorspace will be developed. Rather the amount of the permissive development that is 'converted' into additional floorspace will be dependent, in part, upon market demand.

5.05 The information on exogenous and permissive development is currently obtained from the local planning authorities or where applicable, joint planning teams. For TELMoS, with its extensive coverage of Scotland, this involved contacting over twenty-five separate organisations. The process requires information to be collected on:

- all development had taken place since the base year (2001);
- land allocations that have been identified in local development plans;
- sites with planning permission for development;
- sites where demolition of floorspace is planned; and
- other assumptions that had been made in terms of windfall developments (i.e. those sites that come forward for development but that are not included within any development plan)

5.06 The exercise of consulting local authorities has now been undertaken on two occasions. Following the initial exercise, the feedback from the local authorities emphasised that the planning data needed to be revised on a regular basis in order that it reflect the latest plans and proposals. However an analysis of the results of both rounds of consultation suggests that the information provided is not comprehensive.

5.07 Whilst there is reasonably complete information on residential and industrial proposals and plans there is scant detail regarding future retail and office developments. In part this is a consequence to the way in which these types of development are handled by the planning system. In contrast to the planning for future provision of residential and industrial development, where future requirements are normally calculated and then provided for through land allocations, few local planning authorities calculate the future demand for additional retail and office floorspace. Unless there are committed sites, at the time of the plan's preparation most plans will contain no quantifiable policies for additional development. Rather they will contain policies that identify areas where development is permissible subject either to some form of sequential test or a set of criteria. In both cases the policies are reactive in nature rather than proactive.

5.08 Clearly given the economic forecasts for Scotland, which show a growth in Gross Domestic Product and increases in the number of service sector jobs it appears probable that there will be both an increase in retail spending, that might be expected to generate demand for additional retail floorspace, and a

growing demand for office-based accommodation over and above the small amount that has been identified by local planning authorities.

5.09 In developing the model we would look for ways of modelling the bringing forward of additional floorspace that reflects these underlying economic trends and did not rely solely on the planning policy information that has been provided by the local planning authorities.

A system of Plan Monitor and Manage for Residential developments

5.10 Within Great Britain national planning policy now favours a 'Plan, Monitor and Manage' approach to the provision of housing land. The essence of this system is a three stage approach whereby planning authorities:

- Prepare **Plans**. These set out the scale and distribution of new housing for a 15-20 year period.
- **Monitor** housing requirements in order to maintain an adequate supply of land and to safeguard against over- and under- provision of land
- **Manage** the release of housing land in order to ensure that where there are shortfalls in provision or new projections of need a review of requirements is carried out.

5.11 Typically the approach adopted by local authorities for implementing this system involves housing land surveys in April of each year (these quantify the amount of development and land for development that has come forward during the previous twelve months), the preparation of an Annual Monitoring Report in December and then any subsequent 'management' response being formulated in January to March of the next year. This cycle means that there can be a delay of between twelve and twenty four months between a shortfall or over-provision of housing land occurring and a response being made by the local planning authority.

5.12 TELMoS offers a means of reducing this delay. The process of calculating development for each year of the forecast period means that it is possible to generate forecasts of land take up on a yearly basis. The outputs from these calculations could allow planning authorities to assess the under- or over-provision both in the short and medium term. More so, this information is available for each TELMoS zone. Information at this level allows the authority to identify development 'hot-spots' within their area, where there may be particular problems and where a managed response is required as a matter of priority.

Evaluation of Schemes

5.13 The West Edinburgh example highlighted the way in which TELMoS can be used to explore the impact of a major development, both in terms of the immediate area or a particular transport corridor, but also in terms of its wider implications.

5.14 Currently transport schemes within Great Britain are subject to standardised appraisal. National governments have published prescribed methods (in Scotland, STAG) for evaluating the economic impacts of proposals. There is no similar system for evaluating land allocations or development proposals. In some instances, most noticeably where the transport network is already

experiencing congestion, there will be an appraisal of the transport impacts, however there are seldom any attempts to either determine the economic impacts of a scheme or to rigorously compare two separate options (for development) in terms of their impact - in terms of reducing social exclusion or economic growth.

5.15 We feel that this is a shortcoming of the current British planning process and that TELMoS offers an opportunity to rectify this matter within Scotland. As the examples demonstrate, an integrated land use and transportation model offers an opportunity to measure the impact of a development scheme in terms of :

- impact over time – the model can predict both the short term benefits and those impacts that may take several years to unfold. Examples of the latter were described with the Airdrie-Bathgate example where some of the employment growth took upto ten years to materialise
- impact over space – a national model, such as TELMos can assess the strategic impact of a development as well as the changes that occur in the immediate locality.
- impact for different groups within society – the construction of the model with 18 different types of household and 17 economic activities permits an assessment of the benefits or dis-benefits of a proposal to be assessed in terms of its impact upon key sectors of society. This allows wider social policy aims, for example in terms of reducing levels of social exclusion to be measured.
- environmental impact – calculations of emissions associated with different options can inform the process of shifting from a carbon-dependent urban form to one that is more sustainable

5.16 Ultimately there should be no reason why land use schemes can not be assessed in a similar way to transport schemes.

6 CONCLUSIONS

6.01 TELMoS was developed by a consortium of MVA and David Simmonds Consultancy (DSC) for the Scottish Executive. It was created by linking the Transport Model for Scotland (TMfS) - a large-scale four-stage model - with a land-use/economic model implemented using DSC's DELTA package.

6.02 The examples describe two key types of application of the model. First where the economic and land use impacts of a transport scheme can be quantified, in terms of the changes in population, jobs and economic activity that would occur both in the vicinity of a scheme and also over a wider area; and secondly in terms of the impact upon transport levels that may result from development in one or more areas.

6.03 The experience gained from running these applications has suggested several improvements that would mean that we were able to better model the planning process. Also they point towards applications of the model that could support local planning authorities when considering the future development of their area.

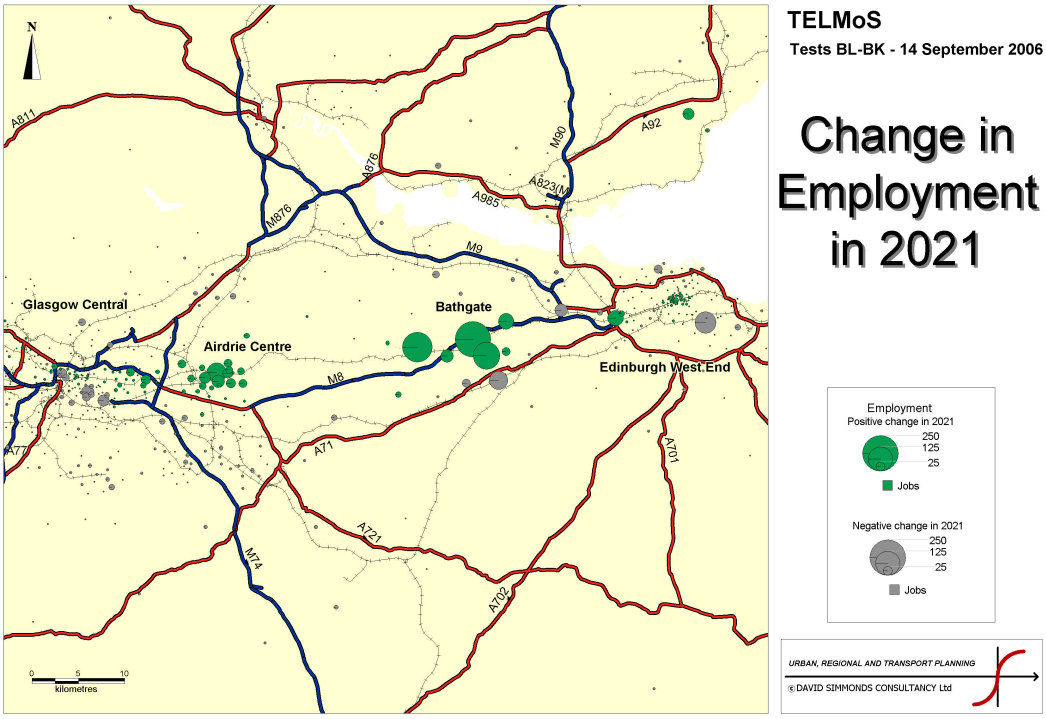
REFERENCES

Simmonds, D. C. (1999): The Design of the DELTA Land-Use Modelling Package. **Environment and Planning B: Planning and Design**, pp665-684.

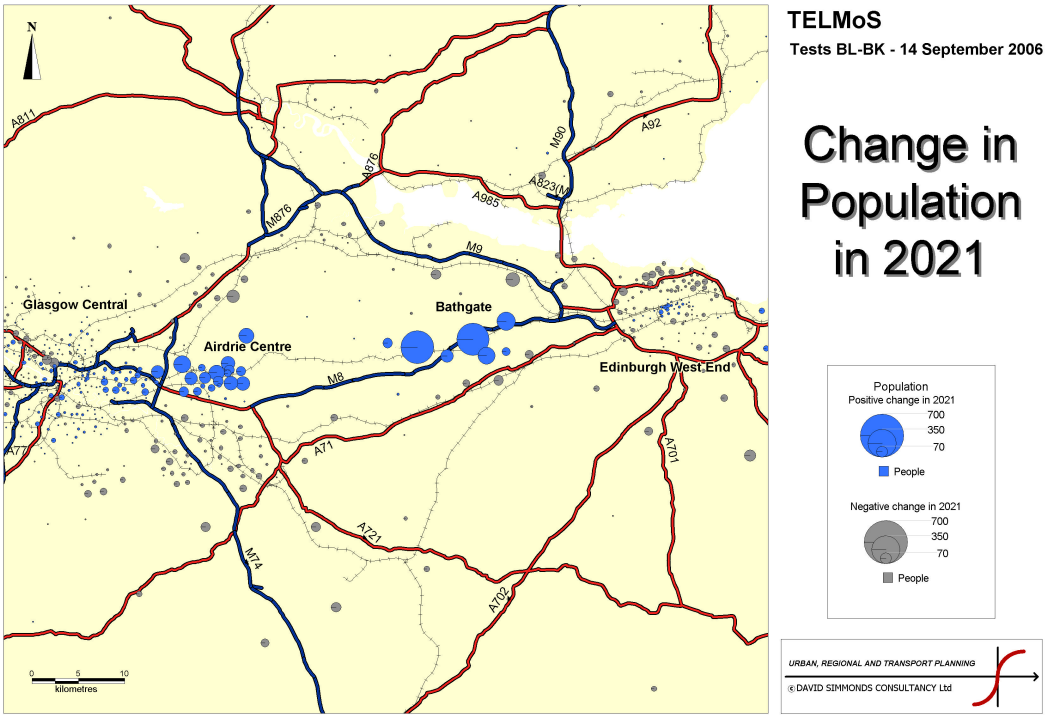
Simmonds, D C and A Skinner (2004): The South and West Yorkshire Strategic Model. In J Stillwell and G Clarke (eds): *Applied GIS and Spatial Analysis*. Wiley, Chichester.

Simmonds, D C and Feldman, O (2005): Land-use modelling with DELTA: update and experience. Paper presented to the Ninth International Conference on **Computers in Urban Planning and Urban Management** (CUPUM). Available at www.cupum.org.

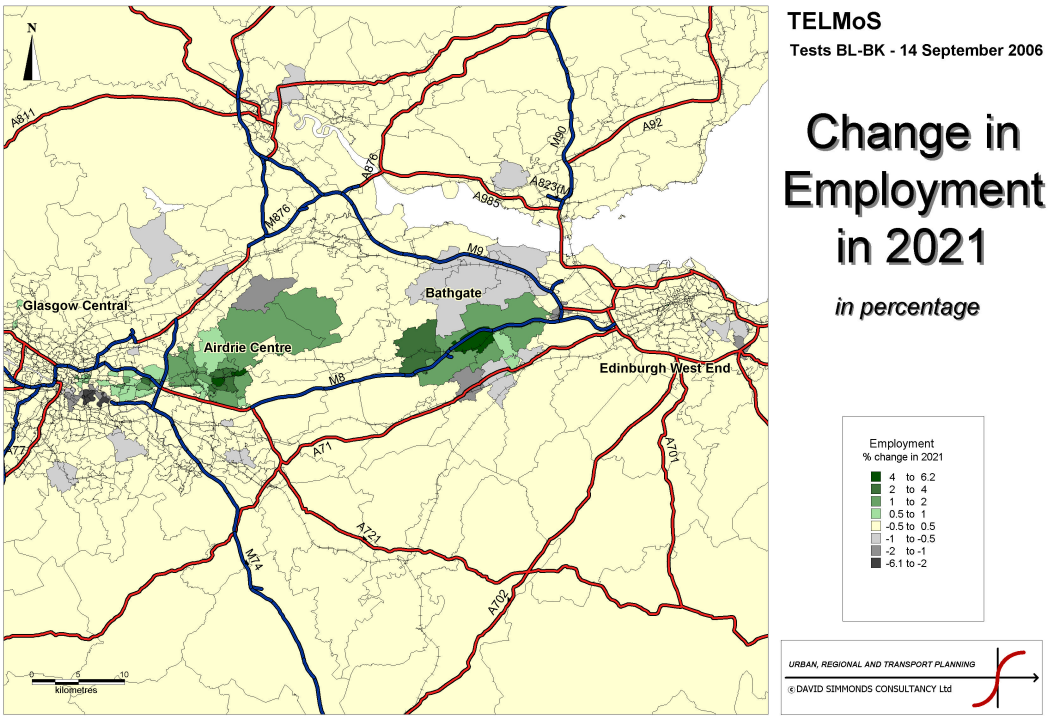
APPENDIX ONE: DETAILED MAPS – AIRDRIE TO BATHGATE



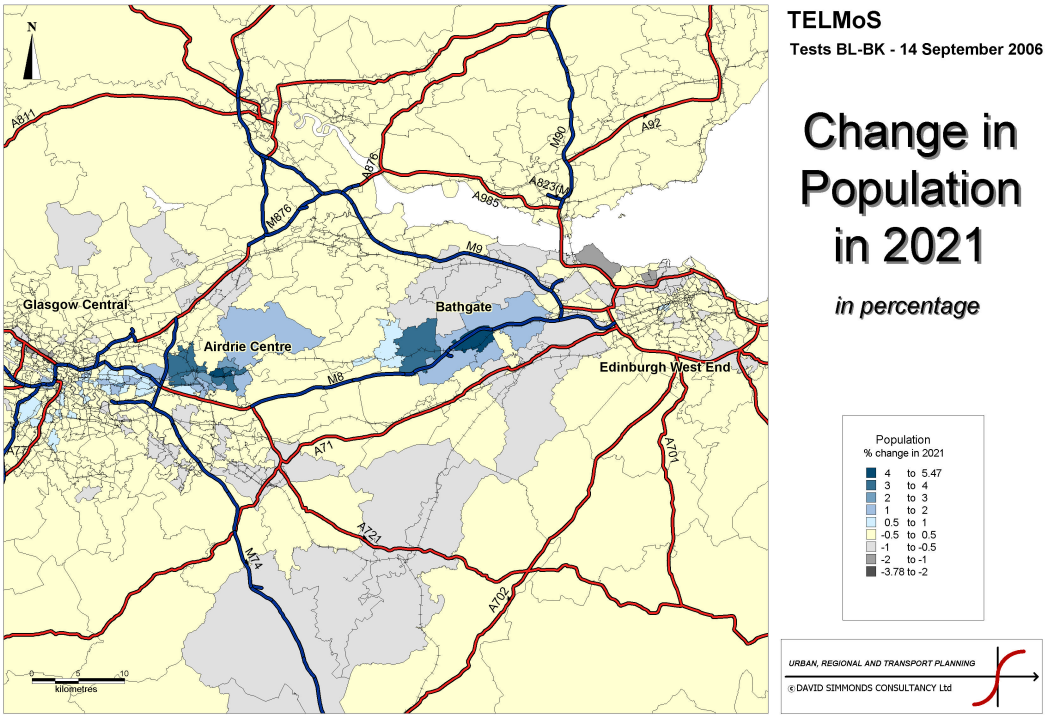
Map 1: Change in Employment 2021, Absolute values



Map 2: Change in Population 2021, Absolute values



Map 3: Change in Employment 2021, Percentage values



Map 4: Change in Population 2021, Percentage values

ACKNOWLEDGEMENTS

TMfS and TELMoS have been developed for the Scottish Executive and are currently maintained and operated under contract to Transport Scotland. The Airdrie-Bathgate analysis was carried out for a consortium of local authorities and other agencies led by West Lothian Council. The West Edinburgh analysis was carried out for the Scottish Executive. The authors are grateful to all of these organizations for their support and advice. The opinions expressed are those of the authors and not necessarily those of the client organizations. The authors are responsible for any errors of commission or omission in the description and interpretation of the model system and of the model results.