

LAND-USE/TRANSPORT INTERACTION MODELLING OF THE BATHGATE-AIRDRIE RAILWAY REOPENING

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1 INTRODUCTION

- 1.01 This paper describes the land-use/transport interaction modelling work carried out by DSC and MVA on the Bathgate-Airdrie railway reopening scheme. The work was carried out on behalf of West Lothian Council, North Lanarkshire Council and others, as input to the Economic and Activity Location Impact report required under Scottish Transport Appraisal Guidance. The scheme is now the subject of a bill before the Scottish Parliament.
- 1.02 The paper concentrates on the modelling and in particular on way in which the modelling forecasts the impacts of transport on jobs and workers. The issues arising in appraisal of these impacts are only briefly considered.
- 1.03 The substance of note is in three parts. The first outlines the modelling approach that has been applied and the background to this. The second describes the impacts that the modelling work has forecast. The third appraises these impacts.
- 1.04 It is important to keep in mind the distinction between the impacts themselves - the forecasts of where, for example, employment is likely to increase or decrease - and the appraisal of these - whether these changes represent benefits, disbenefits or neutral effects.

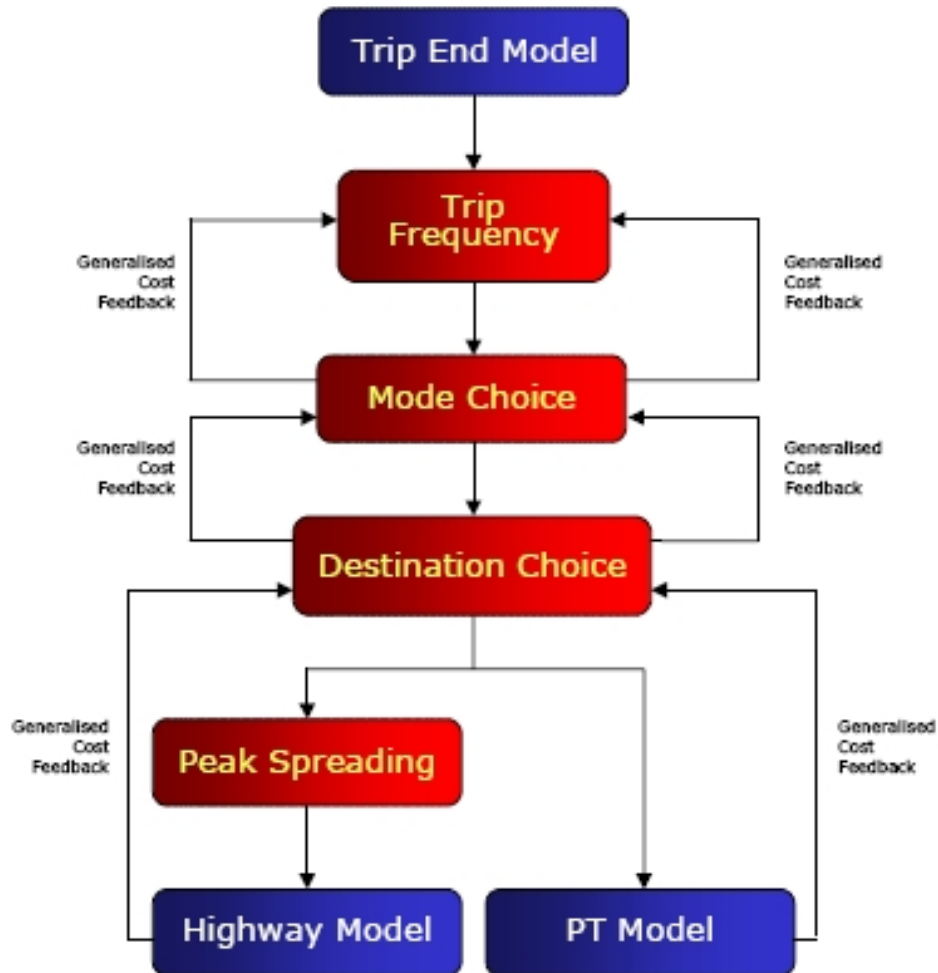
2 MODELLING APPROACH AND BACKGROUND

- 2.01 The modelling approach to Bathgate-Airdrie has made 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 package¹. 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 Details on the basic design of the DELTA modelling system can be found in Simmonds (1999) and Simmonds and Feldman (2005)

2.2 The Transport model

- 2.01 The TMfS (Transport Model for Scotland) model is the name for the current incarnation of the enhanced CSTM3 model, which was initially developed by MVA in 1998.
- 2.02 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.
- 2.03 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.
- 2.04 The simple outline of the model is shown below.



- 2.05 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.
- 2.06 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
- 2.07 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 by the transport model for TELMoS 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”.
- 2.08 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. Within this sequence, the transport model is run, as already mentioned, in 2006 and 2011, with the possibility of a final run at 2021.

2.3 The Land-Use model

- 2.01 The DELTA Land-Use Model of Scotland can be considered as containing three linked sub-models, two of which interact directly with the transport model. Overall therefore TELMoS, the Land-Use/Transport Interaction Model consists of four components. These components and the general linkages between them are shown in Figure 1, and the following paragraphs outline these briefly.
- 2.02 The **transport model** (TMfS) takes the location of activities, by zone, for a given year, and forecasts travel by car and by public transport between zones. In doing so, it estimates the costs and times of travel between each pair of zones, allowing for the congestion caused by the forecast traffic.
- 2.03 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.
- 2.04 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.)

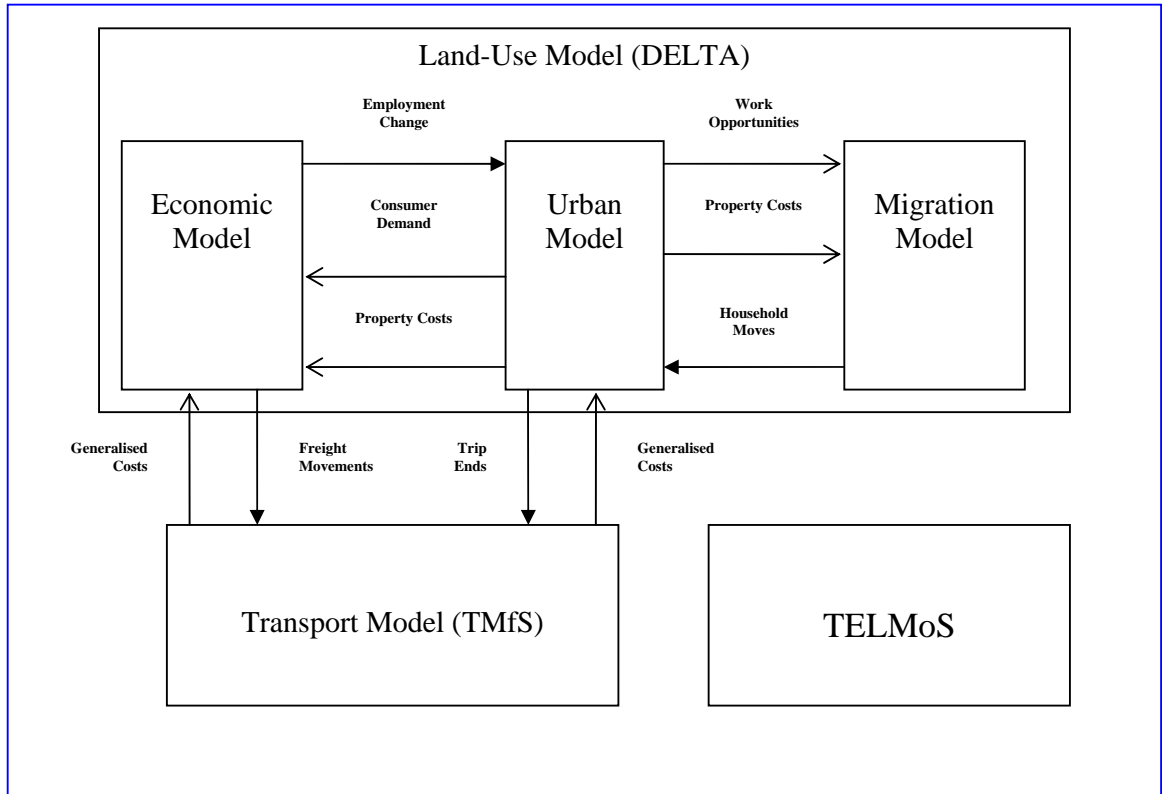


Figure 1 TELMoS: Main model components and linkages

2.05 The **land-use model** consists of three major components; the **economic model** forecasts the growth (or decline) of different sectors of the economy in different sub-regions of Scotland.

2.06 The economic model operates at a regional level (Simmonds and Skinner, 2004), it takes a number of inputs, including independent forecasts of growth in the Scottish economy; 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.

2.07 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.
- 2.08 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 (Scottish Economic Statistics, 2003).
- 2.09 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.
- 2.10 Because the location modelling only applies to new investment, industrial capacity and related employment only gradually responds 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.
- 2.11 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.
- 2.12 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 build spaces 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.
- 2.13 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.
- 2.14 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. The model does take account of different household budgets, and uses these to calculate the consumer demand for goods and services in each area, as an input to the economic model. This is a key stage in modelling any multiplier effects.

- 2.15 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.
- 2.16 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, ie job opportunities and housing costs. Job opportunities are a strong incentive to migration. Housing costs are a weak disincentive.
- 2.17 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.
- 2.18 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.
- 2.19 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.
- 2.20 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.

3 IMPACTS: TESTING AND RESULTS

Inputs

- 3.01 The land-use impacts of a transport scheme (such as the 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.
- 3.02 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 include, in addition to the most direct improvements in the generalised cost of travel across the existing Bathgate-Airdrie “gap”, the consequences of the more frequent services between Bathgate and Edinburgh, the benefits of more direct services to Edinburgh and Lothian from some stations west of Glasgow, and any consequences in terms of decongestion of the road network as a result of travellers switching from car to rail.

3.03 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

3.04 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.

3.05 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.

3.06 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 2 to Figure 5 have therefore been prepared to summarise these impacts for corridors within West Lothian and within North Lanarkshire. In West Lothian, 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. In North Lanarkshire, the Airdrie corridor gains about 1800 residents and just over 600 jobs, with both the Cumbernauld and Motherwell corridors showing slight losses.

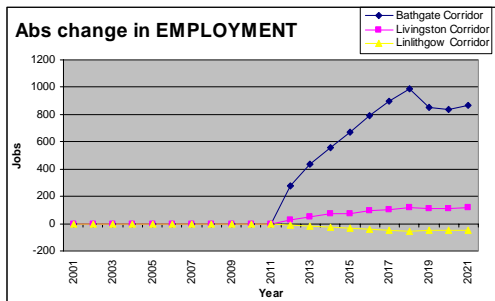


Figure 2: Absolute Change in Employment, West Lothian Corridors

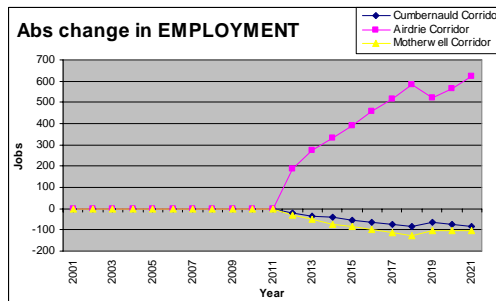


Figure 3: Absolute Change in Employment, North Lanarkshire Corridors

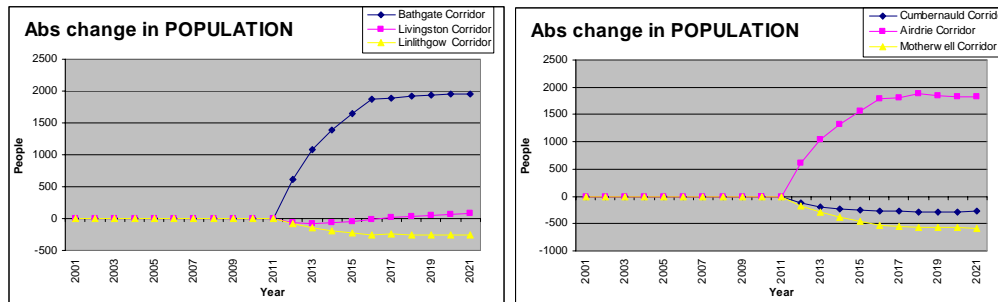


Figure 4: Absolute Change in Population, West Lothian Corridors

Figure 5: Absolute Change in Population, North Lanarkshire Corridors

- 3.07 The graphs also emphasise how the impacts build up over time. For population impacts, most of the impact occurs over five years, with relatively little change thereafter. Employment impacts are generally more spread out over the whole of the decade that has been modelled after the reopening; although we have not modelled the years after 2021, we would not expect significant further employment impacts beyond then. The longer employment responses is partly because many employers take longer to respond to change than households, and partly because 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 different 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.)
- 3.08 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.
- 3.09 The district total impacts, shown below in Figure 6 and Figure 7 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. (The possibility of net gains at national level is not modelled but is considered in the following section.).

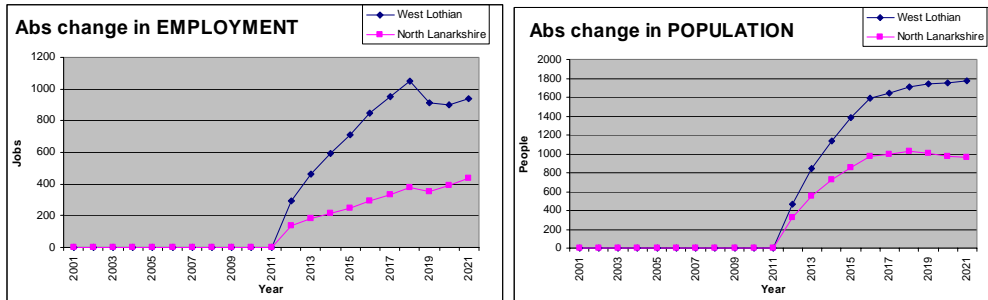


Figure 6: Absolute Change in Employment, West Lothian and North Lanarkshire

Figure 7: Absolute Change in Population, West Lothian and North Lanarkshire

4 APPRAISAL

- 4.01 We note here how the appraisal was carried out, without going into the details of the conclusions.
- 4.02 In addition to the influence of the land-use results on the Transport Economic Efficiency, through the projected changes in activity location, the project was appraised in terms of its Economic and Activity and Location Impacts (EALI), which contributes to the economic strand of project appraisal as outlined in Scottish Transport Appraisal Guidance (STAG).
- 4.03 In future it may prove possible to extend the appraisal to include analysis of Land-Use/Transport Economic Efficiency effects, in particular the presence of a detailed Land-Use model would allow for the assessment of a number of **wider benefits**, related to labour force participation, agglomeration effects on productivity growth and differential pure productivities between regions.
- 4.04 It is important to note that appraisal is undertaken for Scotland as a whole, as such the predicted increases in employment in the Airdrie-Bathgate corridor is simply a redistribution of what is assumed to be a fixed number of jobs, not a benefit in itself. The EALI appraisal therefore addresses the extent to which the scheme contributes to the following
- Increased employment in areas officially identified as in need of economic or social assistance
 - Increased activity in areas which are identified as key growth locations in approved planning documents
- 4.05 Key to this appraisal is the comparison of the model effects with both the relevant local Structure Plans and the location of deprived areas, as indicated by maps of Assisted Areas, Objective 2 designation and Community Regeneration Fund areas.
- 4.06 The modelling results indicate that the reopening scheme will have positive impacts on the numbers of residents and numbers of jobs in the corridor it serves. There will be some redistribution of activity within the West Lothian and North Lanarkshire areas, but both districts show net gains in both residents and jobs.

- 4.07 The impacts are modest in percentage terms, though the absolute figures involved – nearly 950 additional jobs and 1800 additional residents in West Lothian - are significant. The scale of the impacts is a result of the limited role which public transport plays in accessibility, balanced against the fact that this particular scheme is potentially important for access to Central Glasgow and Central Edinburgh where public transport is more important than average.
- 4.08 The appraisal of the impacts indicates that the scheme will assist the achievement of Scottish policies as set out in the Assisted Areas map, see Appendix One. At a more local level it will on balance also give some support to the policies set out in the two relevant Structure Plans and in the Objective 2 designation for parts of West Lothian, and in relation to deprived areas particularly towards the western end of the corridor.
- 4.09 It is also important to note that the appraisal process concentrates on what is required for STAG and hence on the issues of whether it is appropriate for the Scottish Executive to support (and spend public money on) the scheme. This Scotland-wide appraisal may be different from that of the local authorities affected. For example, the Executive might see no benefit to Scotland as a whole in encouraging employment growth in one particular area rather than another, whilst the local authority of that area might have strong views as to which outcome was preferable.

5 CONCLUSIONS

- 5.01 The project has demonstrated the use of a major land-use/transport interaction model to test the impacts of an important transport proposal. The work benefited greatly from previous investment by the Scottish Executive in the TMfS/TELMoS system, which has been used for a variety of studies which may not individually have justified the implementation of such a large-scale model system. The model is of course open to improvement, and we hope to implement some significant enhancements within the new contract which MVA/DSC have recently been awarded by Transport Scotland (who are now responsible to the Scottish Executive for the continuing development and use of the model). We also note the possibilities of further advances in the methodology for appraisal in schemes where land-use/transport interactions are being considered.

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

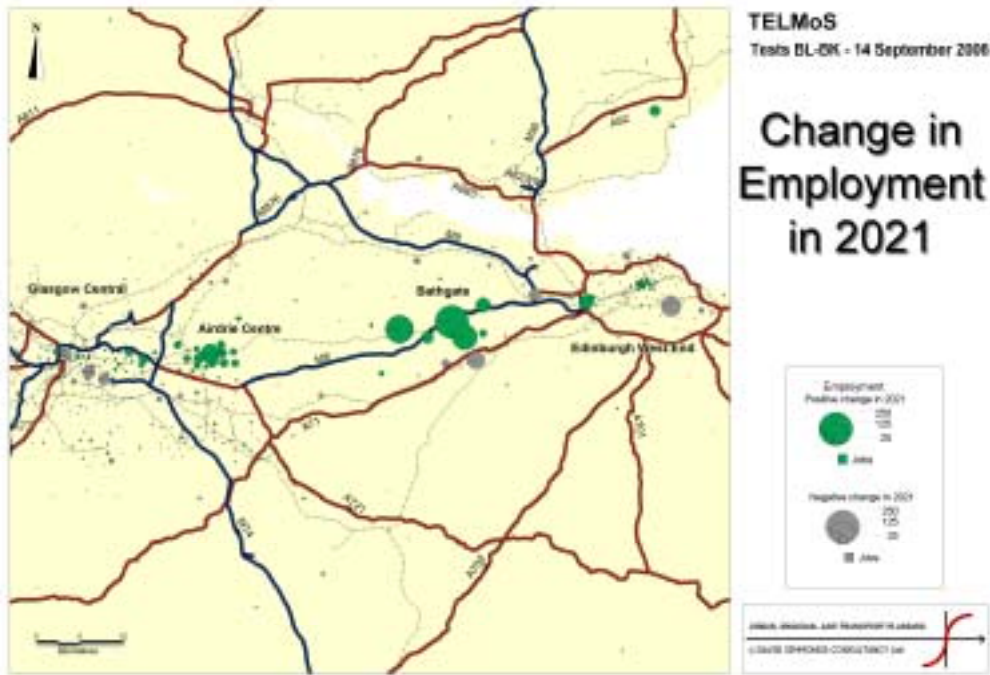


Figure 1: Change in Employment 2021, Absolute values

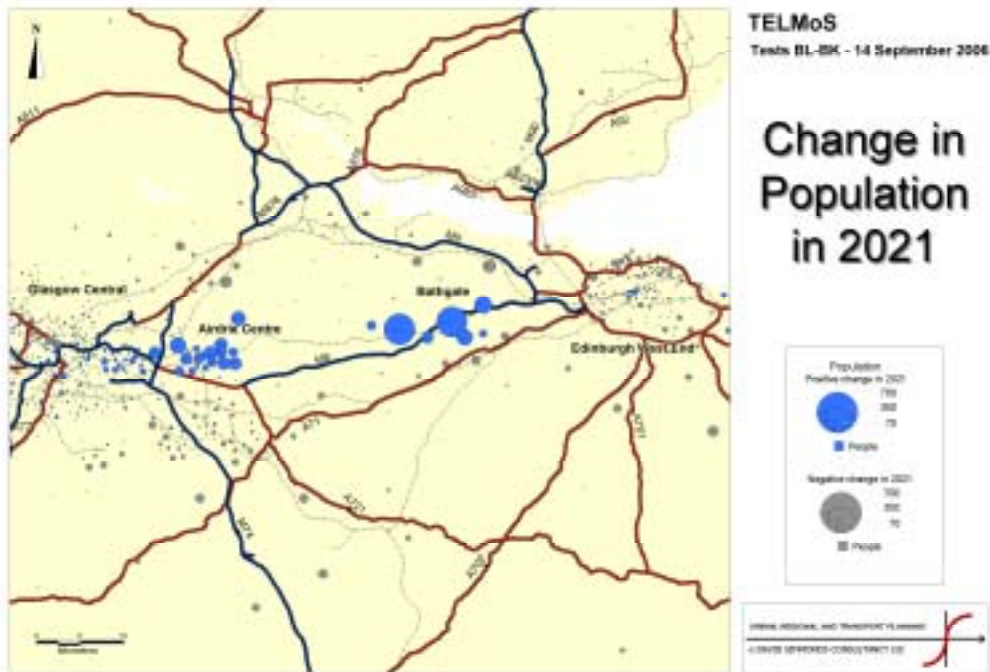


Figure 2: Change in Population 2021, Absolute values

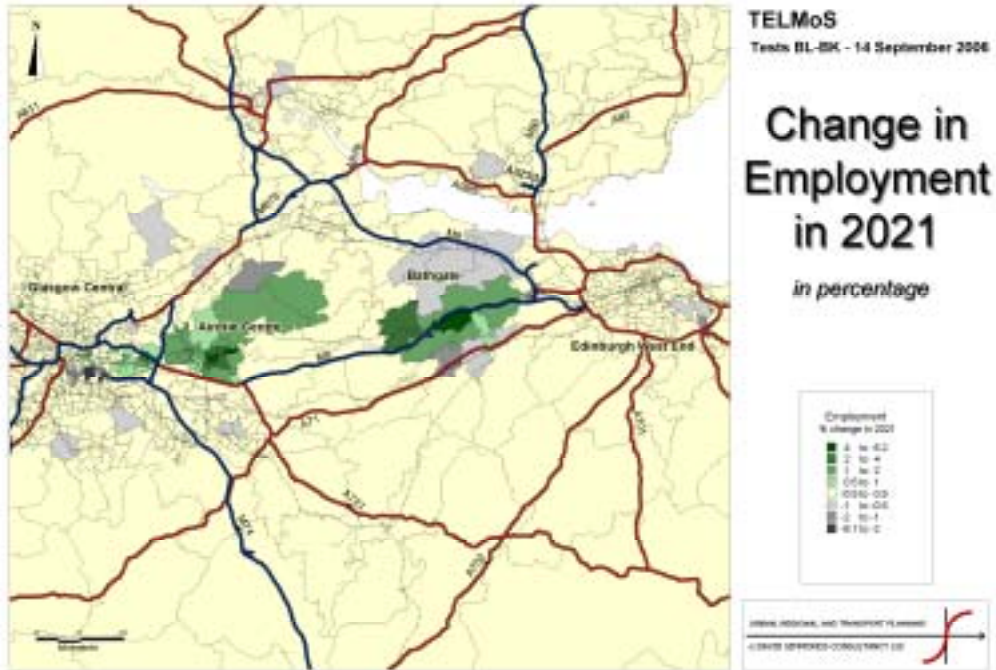


Figure 3: Change in Employment 2021, Percentage values

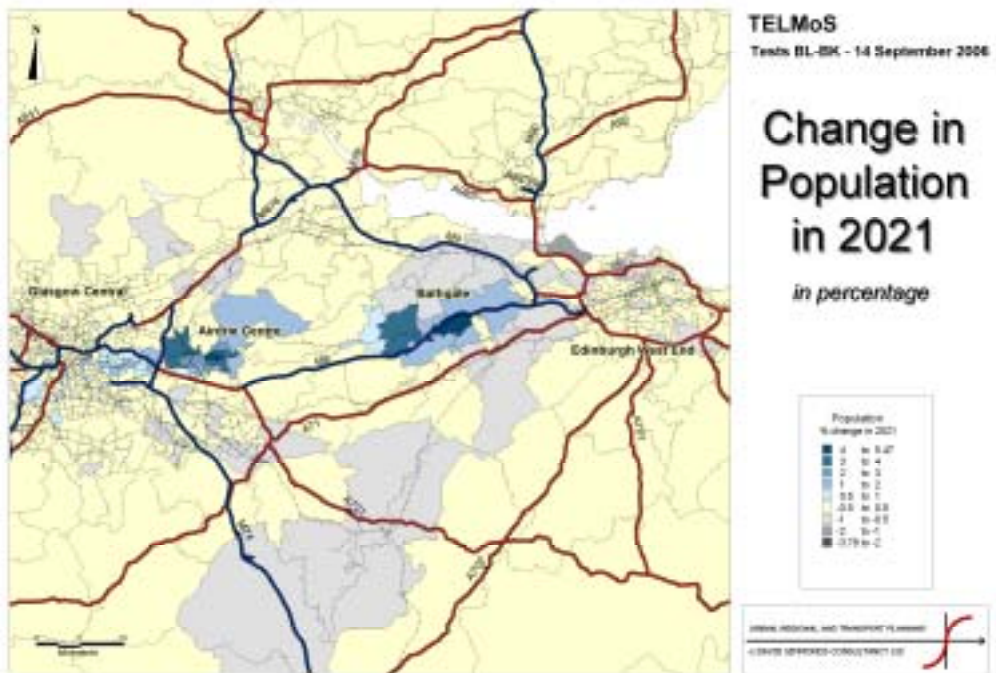


Figure 4: Change in Population 2021, Percentage values

Assisted Areas Map for Scotland: 2000 - 2006

Notes:

- 1 To find out whether or not a particular location is in a Development Area, contact the Investment Assistance Division of the Scottish Executive Enterprise and Lifelong Learning Department on 0141 242 5676
- 2 The ward boundaries used to create the map below are "best fit" boundaries. A full list of the 1991 Local Authority Wards designated as Assisted Areas was published on 28th July 2000.
- 3 The European Commission in approving the new Assisted Areas Map also set ceilings on the levels of investment aid which may be offered in particular regions. These ceilings are reflected in the map below.

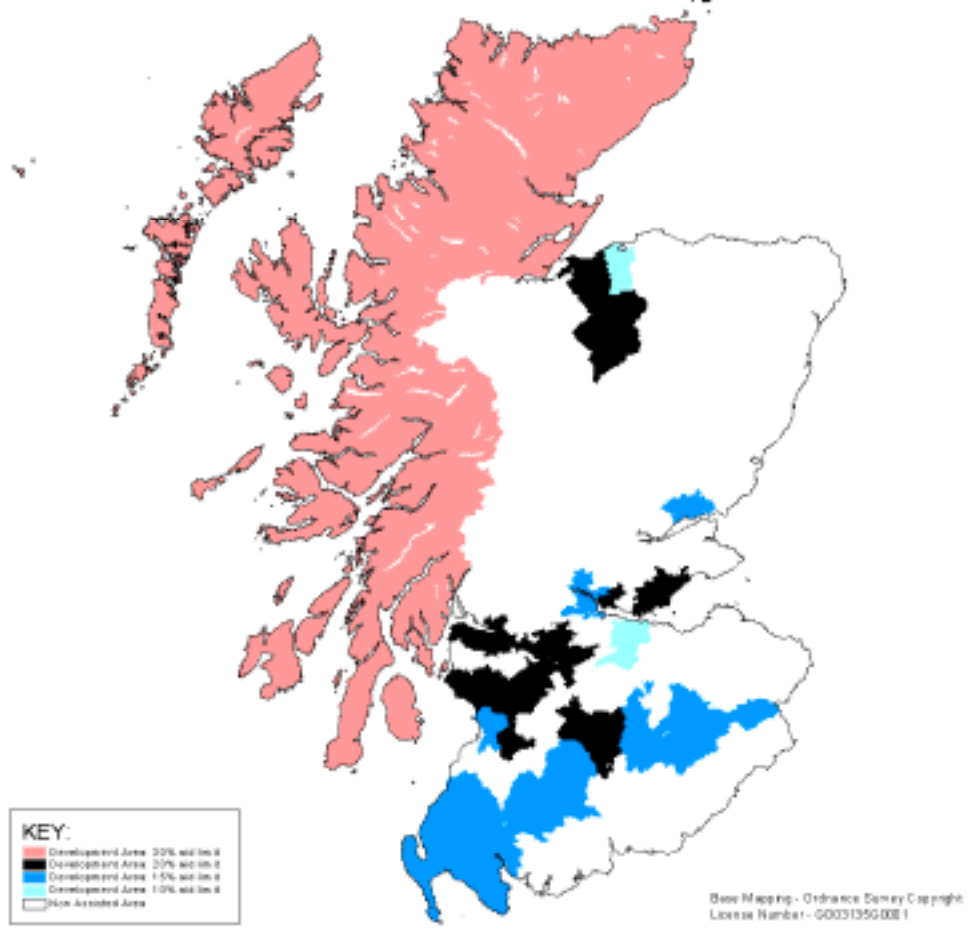


Figure 5: Assisted Areas Map for Scotland

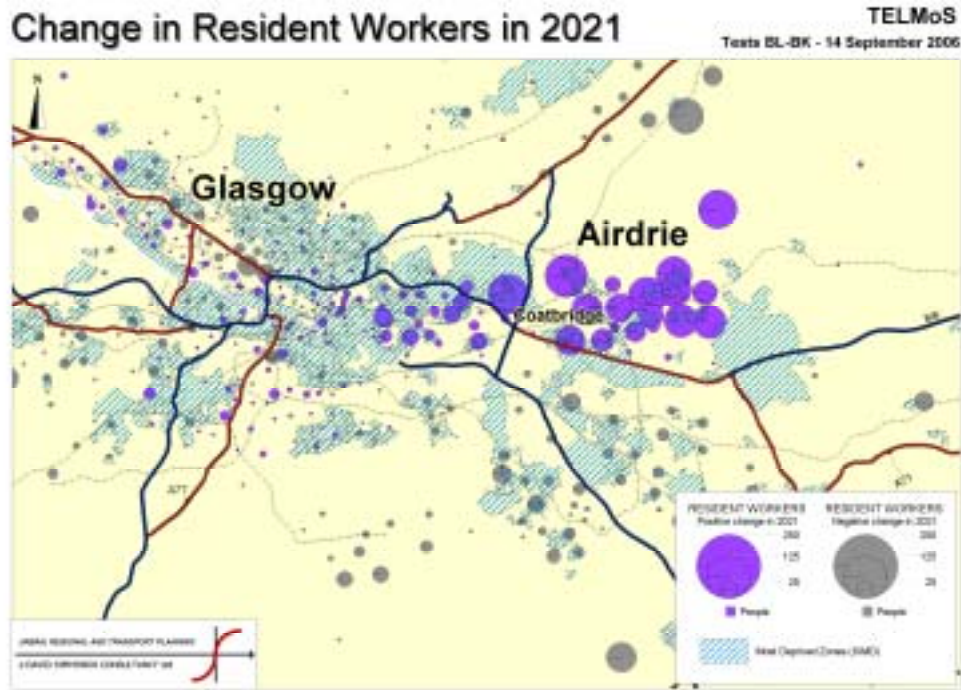


Figure 6: Change in Resident Workers and Areas of High deprivation, Airdrie

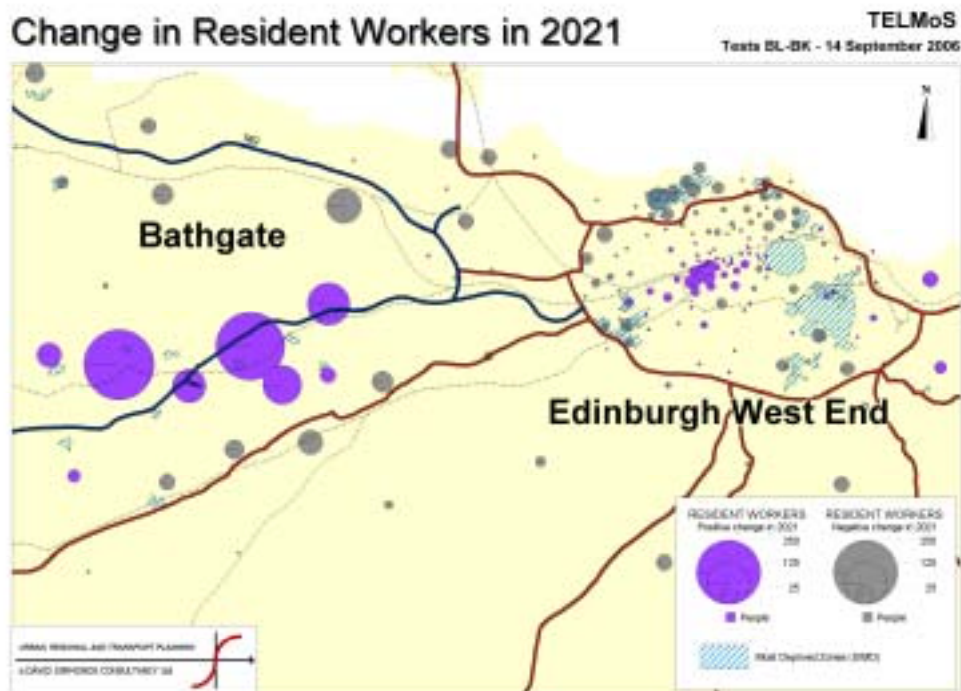


Figure 7: Change in Resident Workers and Areas of High deprivation, Bathgate