SITLUM – THE STRATHCLYDE INTEGRATED TRANSPORT/LAND-USE MODEL

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Abstract. The Strathclyde Integrated Transport/Land-Use Model (SITLUM) was developed by TRL and David Simmonds Consultancy (DSC) for Strathclyde Passenger Transport (now Strathclyde Partnership for Transport). SITLUM links an earlier application of TRL's Strategic Transport Model (STM) package for the Strathclyde area (centred on Glasgow) to a new implementation of DSC's DELTA land-use modelling package. The paper describes the design of the model and presents some example results.

1. Introduction

As part of their strategic modelling capability, Strathclyde Passenger Transport (SPT) have, for some years, used the TRL's Strathclyde Strategic Transport Model (SSTM) as a "policy filter" in conjunction with a large scale network model, the Strathclyde Integrated Transport Model (SITM). SSTM has also been used to assist policy formulation by the Structure Plan Teams in the Glasgow and Clyde Valley and in Ayrshire. To allow SPT to extend this into modelling the interaction of land use and transport processes, TRL, as lead consultants, and David Simmonds Consultancy (DSC) were commissioned in 2003 by SPT to design and implement the Strathclyde Integrated Transport and Land-Use Model

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(SITLUM). This integrates the state-of-the-art DELTA land-use/economic model with an enhanced version of the SSTM.

Both SSTM and DELTA exist within the SITLUM system as separate programs. Both SSTM and DELTA are run in sequence over the range of years to be modelled. During this process they exchange information. SSTM provides DELTA with accessibility (travel costs) and trip data for movements between study area zones; DELTA generates planning data (influenced by travel costs, taking into account time lag effects) to SSTM. The system also consists of a third program: the SITLUM user interface. This is an extension of an earlier SSTM which allows the user to create test scenarios, create and initiate program control files and view both transport and land-use outputs from a graphic user interface.

2. DELTA

Work on development of DELTA started in 1995 in response to a perceived demand for a new "land-use" modelling package with two key characteristics. The first, practical characteristic was that the model should be suitable for use as an add-on to otherwise free-standing transport models, in particular to "strategic" transport models [3]. The second, theoretical requirement was that the model be constructed in terms of processes of change, drawing on the enormous range of research carried out in urban and regional economics, geography, demography, sociology, etc. Further detail of the original design is published in reference [4] and a recent update in [1].

2.1. Land-use/transport interaction using DELTA in SITLUM

The overall design of a DELTA-based model consists of four components, as illustrated in Figure 1, namely

- the transport model (to which DELTA is linked);
- the economic model;
- the urban land-use model;
- the migration model.

Of these, the transport and urban models work at the level of zones, whilst the migration and economic models work at the broader level of areas. Areas typically correspond to travel-to-work areas, at least within the region of main interest; zones represent finer units within these areas (or within the area we are concentrating on).

The **transport model** takes inputs which describe activities (different categories of residents and jobs) by zone, for a given year. From this and from input transport system data it forecasts travel by car and by public transport. In doing so, it estimates costs and times of travel between each pair of zones, allowing for congestion caused by the forecast traffic.

The **economic model** forecasts the growth (or decline) of the sectors of the economy in each of the areas modelled. Its inputs include forecasts of overall growth in output and productivity. The forecasts by sector and area are influenced by

- costs of transport (from the transport model)
- consumer demand for goods and services (from the urban model)

• commercial rents (from the urban model).

Forecast changes in employment by sector and area are passed to the urban model. Freight transport outputs can be passed to the transport model.

The **urban model** forecasts the zonal location of households and jobs within the areas that are modelled in detail. Locations are strongly influenced by the supply of built floorspace. Locations are also influenced by accessibility, with different measures of accessibility influencing different activities, and by environmental variables. Households are influenced by accessibility to workplaces and services. Businesses are influenced by accessibility to potential workers and customers.

The locations of households and jobs are fed back to the transport model to generate travel demands. Household numbers are also used to calculate consumer demand for goods and services in each area, for use in the economic model. The rents arising from competition for property in each area affect both the economic and migration models. Information on job opportunities is passed to the migration model.

The **migration model** forecasts migration between areas within the modelled area. (Movements within areas are forecast in the urban model.) The inputs to this model include job opportunities and housing costs, from the urban model. Job opportunities are a strong incentive to migration; housing costs are a generally weak disincentive.

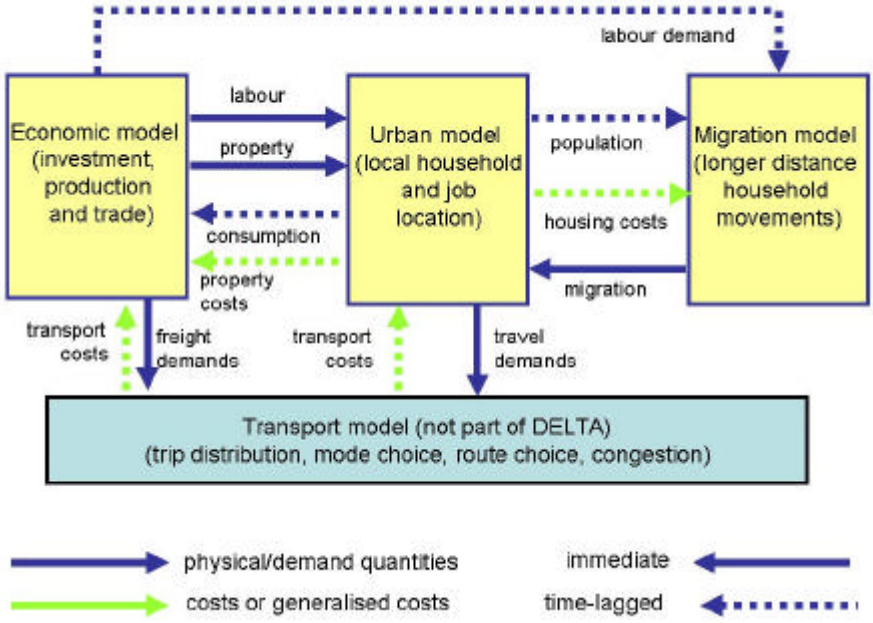

Figure 1 Overall structure of DELTA model

There are complex possibilities for feedback between the four components outlined above. For example, it is possible for an improvement in transport to generate economic growth, which generates additional travel, which may cause increased congestion and some worsening in transport conditions.

2.1.1. Sub-models within DELTA

The original DELTA package was intended to model a single compact area, with a given economic and demographic scenario for the total change in that area. It therefore consisted solely of the urban model (linked to a transport model), which at first consisted of five sub-models:

- the **Transition and growth sub-model**, dealing with household/population change and employment growth factors;
- the **Location and property market sub-model**;
- the **Employment status and commuting sub-model**;
- the **Development sub-model**;
- the **Area quality sub-model**.

The name DELTA was discovered as an acronym for these five sub-models. The **car-ownership sub-model** was added in the application to Greater Manchester [2].

The **economic** and **migration** models were added to allow the model system to represent either the wider interactions between a city area and its neighbours (without modelling other cities in any detail) or to model a region containing a number of urban areas. The main linkages between the sub-models within a one-year period are shown in Figure 2. This allows SITLUM to take account of the interactions between the main area of interest and the rest of Scotland.

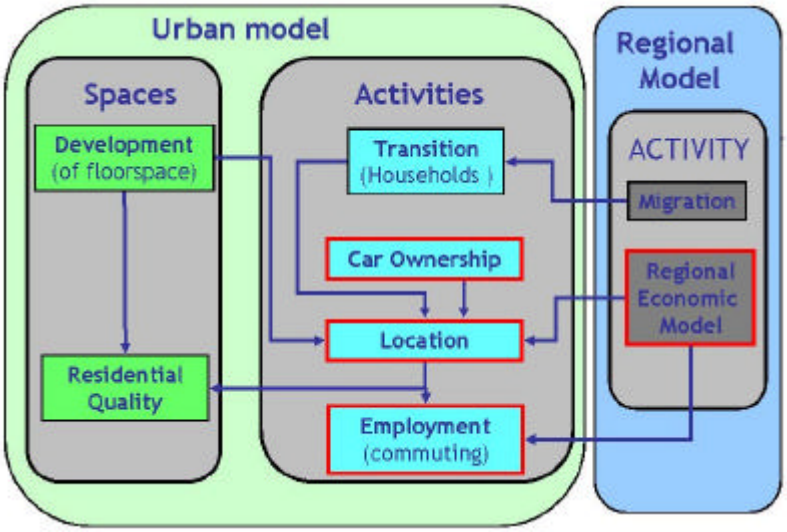

Figure 2 Sub-model sequence within a DELTA one-year cycle

3. STM

"STM" refers to the software package; "SSTM" to the Strathclyde application. The STM software was originally developed at TRL to test multi-modal transport policies in the

Greater London area. The key design objective was a high-speed desktop tool which planners and policy makers could use to assess the potential impacts of policy levers applied either singly or in combination. Users would be able to identify, at an early stage, promising strategies on which more detailed investigation could be concentrated.

STM was therefore designed to model travellers' responses to the many different components of generalised travel cost, but without using a detailed representation of transport networks and route choice which accounts for a substantial part of the run time of large-scale models. An STM study area usually has a relatively smaller number of zones when compared with large assignment models; 173 zones have been used in SITLUM to model the Strathclyde / Ayrshire area. To incorporate long range movements and land-use interactions, the zonal system extends over the whole of Scotland; the transport model, SSTM, also includes a zone for England and Ireland.

The modelled modes include car, public transport and non-motorized modes. There is also provision for the modelling of new Park and Ride schemes, and new Light Rail links and the impact of new railway stations. STM trip purposes cover home-based purposes (work, education, social/leisure, etc) and non-home-based trips. Two time periods are modelled: the am peak and interpeak. Levels of travel demand in STM are driven by planning data describing the spatial distribution and composition of population, jobs and car ownership. In SITLUM these are provided by DELTA. SSTM can also be run within SITLUM without interacting with DELTA: either pre-existing DELTA outputs can be used or exogenous planning projections can be created within the STM software using TEMPRO growth factors or they may be user supplied.

To increase robustness, STM is "incremental", i.e. it uses demand models (distribution/modal split) which derive future patterns of modal share and distribution from cost changes and the corresponding patterns in a base year. Highway travel times are calculated in STM using zonally-based speed flow relationships for different road types. Road and rail trips follow routes through the zonal system based on the actual networks. Provision now also exists for using different highway routings in forecast years arising from changes in the road networks. STM iterates so as to converge towards equilibrium between demand levels and supply costs.

The user can apply a range of transport policy levers over modelled forecast years: cordon charges, parking, public transport supply and fares; as well as explore the implications of scenario changes in terms of demography and car ownership, real earnings and fuel prices. STM can then run in "time-marching" fashion over the specified forecast years to provide outputs for those years, in interaction with DELTA.

A variety of STM outputs are available relating to congestion, modal shift, emissions and road safety. Cost-benefit calculations can also be enabled. A striking feature of STM is its Graphic User Interface (GUI) with an interactive map which gives exportable displays of changes in policy impact measures for comparison scenarios and GIS-style "thematic" mapping of outputs – the latest version of STM (used in SITLUM) also allows land use variables to be displayed.

4. SITLUM application

Figure 3 shows the study area of the Strathclyde Integrated Transport/Land-Use Model.

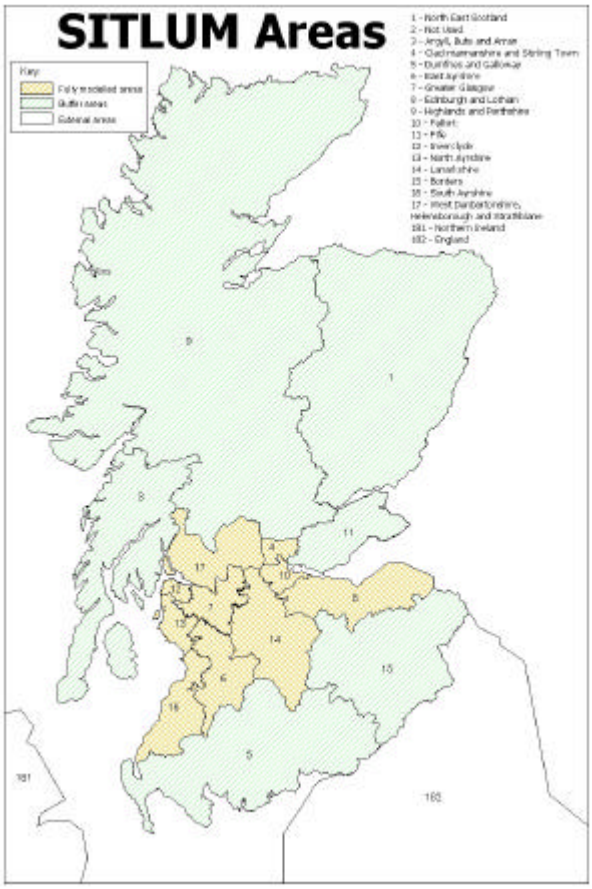

Figure 3 SITLUM study area

4.1. Database files

The initial SITLUM population and household database files have been created using the results of the 1991 and 2001 census. The major task in processing the census data is to disaggregate, for each SITLUM zone individually, the households and their members into the household and person categories used in this application of DELTA. The household classification takes account of household composition/age and socio-economic group; the members of these households are identified as children, working, non-working or retired. Employment is categorised by sector and by socio-economic group. The initial database also measures the floorspace available to these activities in each zone, in terms of quantity by type (residential, retail, office etc), the rental value of each type in each zone, the quantity of each type that is vacant, and, for housing, a quality measure.

It is important to note that the base year (2001) situation is directly input to the model and does not have to be reproduced within the model; the model forecasts the changes over time from that situation.

4.2. The economic and demographic scenario

The SITLUM inputs that create the economic and demographic scenarios have been defined so as to reproduce the rates of change in economic activity, employment and population that are used in other aspects of Scottish planning. The concern in using SITLUM is to understand how land-use and transport plans will affect the distribution of employment and population within Scotland.

4.3. Reference case and example results

The base year in the SITLUM application is 2001 and the reference case is run to produce a forecast period of 20 years, until 2021. The following policy test has been devised by DSC purely to show the response of the system to such inputs and does in no way represent policy of any other party.

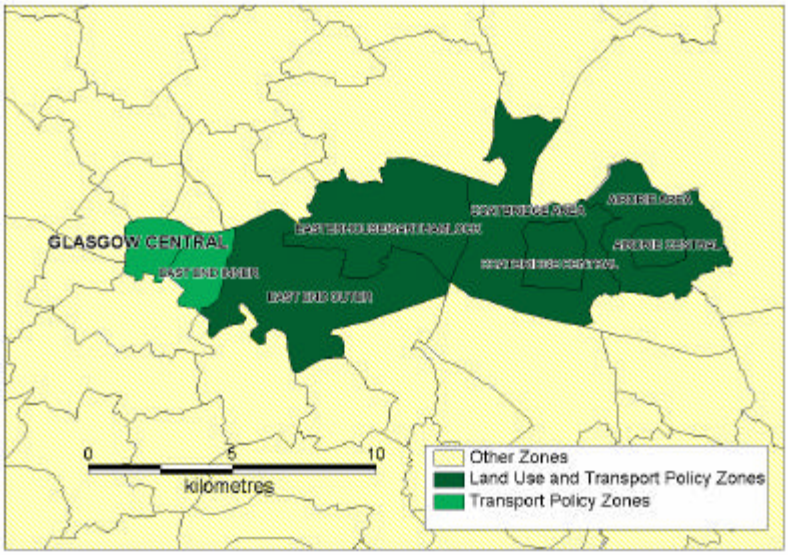

Figure 4 Airdrie Corridor

The policy that is implemented is a new, very high quality LRT route heading east from central Glasgow reaching as far Airdrie town centre and serving all eight zones that the route passes through .Figure 4 shows this "Airdrie Corridor". The hypothetical LRT scheme is assumed to start operation in 2005. In addition, from 2005 development of an additional 7000 dwellings is allowed along the corridor. The following inputs/options have been used to define the LRT scheme:

Figures 5 and 6 show summary indicators of the scale and pattern of the main land-use impacts. A wide variety of other indicators are available. The ability to examine the interaction between land-use and transport measures, and to forecasts their impacts over time, is proving valuable in planning practice.

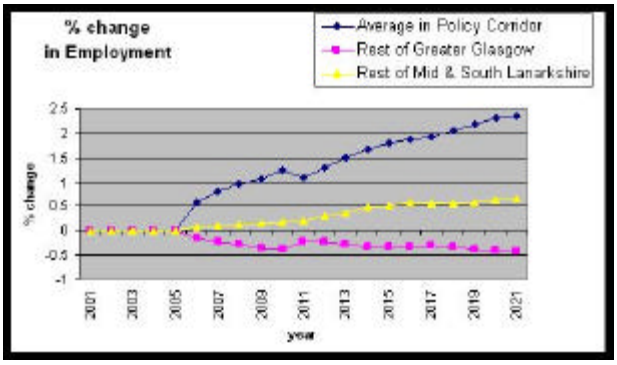

Figure 5 Employment impact in Airdrie Corridor

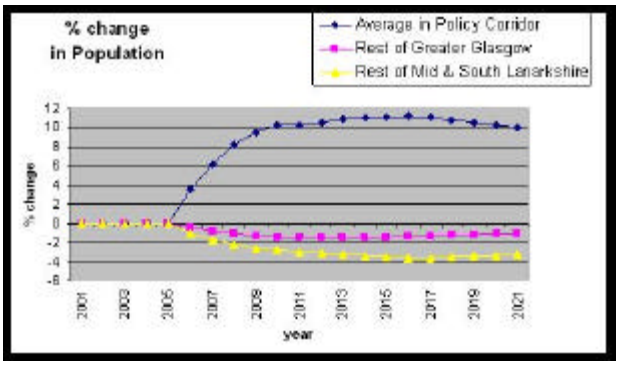

Figure 6 Population impact in Airdrie Corridor

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