Planning in a changing world: the use of SITLUM to inform policy and strategy development

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1 Introduction

1.1 Background

Over the past few decades, the demographic and economic landscape of Scotland has changed; so too has the provision of public transport, road infrastructure and housing and employment floorspace. Over the next few decades, yet more change will occur – the exact form this change will take, we cannot know for sure. Planners are faced daily with the questions, '*how can we meet social, economic and environmental objectives? What is the most efficient way of accomplishing them?'* To answer these questions, a planner needs to understand the status quo, and what might happen in the future, should the status quo be allowed to forge its path unceasingly. They need to determine how certain factors might influence transport demand, and they need to be able to confidently adapt policies around these demands.

The work of a great many organisations, public and private, can be combined with accrued theoretical knowledge and practical expertise to create effective strategic models. Figure 1 demonstrates two separate continua, one showing network detail and one showing complexity. As we traverse either of the continua, the amount of time to execute a model run increases. In an ideal world, a model would be infinitely detailed, both spatially and in its scope. However, the reality of trying to at once to make sense of the world as it changes, and to respond in an effective way, means a balance needs to be struck. So how do we find this balance?

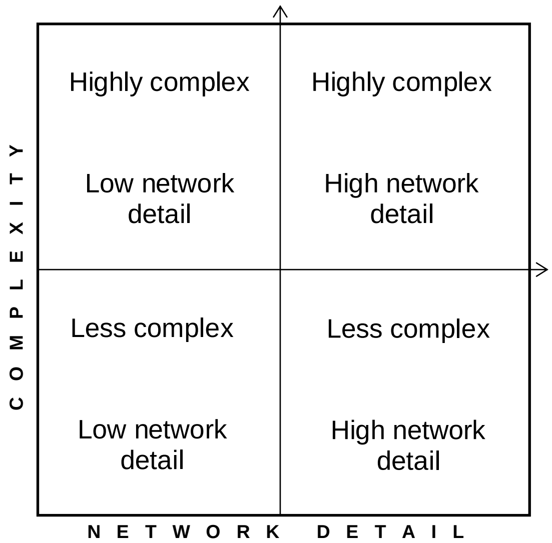

Figure 1 Complexity vs. network detail in strategic transport/land-use modelling

1.2 Multi-level strategic modelling – SITLUM and SRTM

An effective way of dealing with the trade-off between time and complexity is simply to ignore it – or rather, to *use the most effective tool for the job at hand* so that the trade-off is not so large. To get reliable results as quickly as possible, one can rely on expedient, efficient and strategic methods to gain necessary insight, before doing more detailed (though more costly and much more time-consuming) appraisal work later. This is the approach that has been effectively put into place in SPT (Strathclyde Partnership for Transport) with SITLUM (Strathclyde Integrated Transport and Land-Use Model).

SITLUM is a fully-integrated land-use with transport interaction (LUTI) modelling package, covering the whole of Scotland, with particular emphasis on the Strathclyde region. It contains a DELTA land-use model – developed by David Simmonds Consultancy (DSC), coupled with a strategic transport model (STM) – developed by the Transport Research Laboratory (TRL). Focusing on local planning and public transport interventions, the model is particularly useful for impact analysis and scheme prioritisation for infrastructure and investment planning. In section 0, the scheme appraisal methods available in SITLUM will be outlined in more detail.

The approach taken with SITLUM is appropriate for its purpose, as it fits well alongside SPT's regional transport model (formerly SITM4, currently SRTM) and the regional transport strategy. Where SITLUM provides a sound basis from which to test arrays of different scheme variations, SRTM allows for lower-level, more detailed (spatially and computationally) outputs, while also taking some input from SITLUM itself. Consequently, SITLUM runs a full forecast in a few hours (or a single year in 10-15 minutes); SRTM many multiples of this. Using the multi-level approach, SRTM can be run only when there is confidence in a given set of inputs, avoiding unnecessary use of resources.

1.3 LUTI modelling

LUTI models are forecasting systems which combine land-use and transport modelling in such a way that

- future land-uses determine (most of) the demands for transport – in particular by defining where residents will live, and where jobs and services will be located
- the future performance of the transport system – given those demands – influences (some aspects of) future land-uses, not only in terms of changes to the physical use of land but more importantly in terms of where households and firms locate.

The objective in using LUTI models, as with stand-alone transport models, is of course not just to make forecasts of what will happen in future, but to test how those forecasts respond to different assumptions or plans. This is illustrated in Figure 2 below, which shows

- across the middle of the diagram, the model itself, with the interaction of land-use and transport now shown as a loop (in practice, it works in the time-marching sequence which is illustrated in Figure 3 and discussed further below);
- entering the model from above, 'top-down' economic and demographic scenarios which define the overall context for the model;
- entering the model from below, 'bottom-up' planning and transport interventions which need to be tested. (In practice these may include economic development or regeneration measures, as well as those which are strictly 'planning' interventions; all of the interventions can in general involve investment, regulation or pricing (e.g. taxation), either singly or in combination.

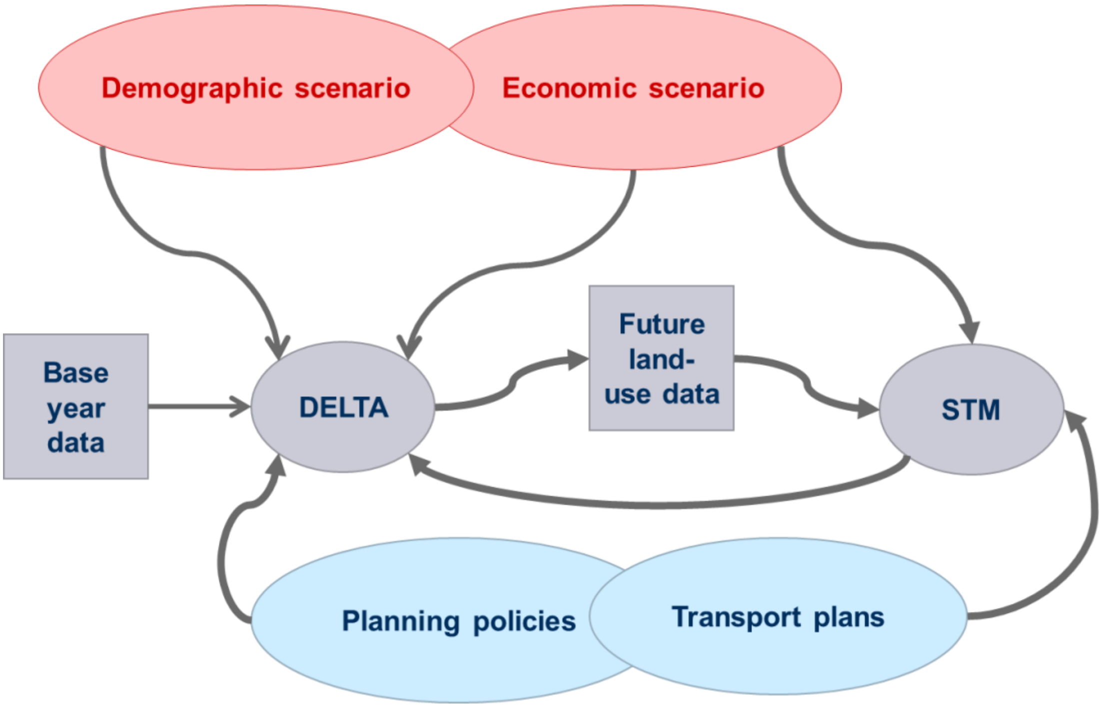

Figure 2 Scenarios, policies and model

The way in which land-use and transport interact in forecasting can vary, with some models iterating land-use and transport forecasts to equilibrium in a given year (just as transport demand and supply are more commonly iterated to equilibrium); but the most common approach is the 'time-marching' framework in which land-use change is modelled over time, gradually responding to changes in transport, and transport is modelled as responding to the land-use pattern at particular points in time.

Figure 3 demonstrates how the land-use and transport components of SITLUM interact. As the transport model receives journey-to-work matrices, population, employment education, floorspace and car-ownership proportions from the land-use model, the land-use model receives generalised cost matrices from the transport model.

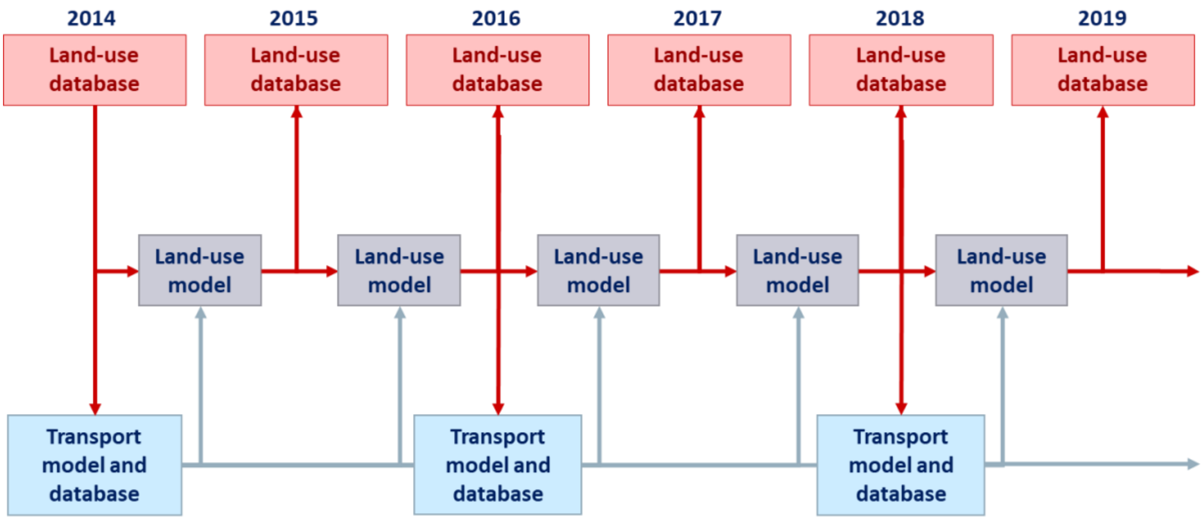

Figure 3 Time-marching diagram of full-LUTI SITLUM run

2 SITLUM: An overview

2.1 Geography

Figure 4 details the model's geography. The majority of modelled processes operate at a zone level, of which there are 268; the most detailed geography is in the Strathclyde region, comprising 212 zones. Other, more regional-economic, processes operate at the more spatially aggregate level of macrozones. For the interface with SRTM, key databases are produced at a more spatially *dis*aggregate level, mirroring the transport model zones. (As a point of reference, SITLUM disaggregates outputs to the RTM zones using these spatially disaggregate databases).

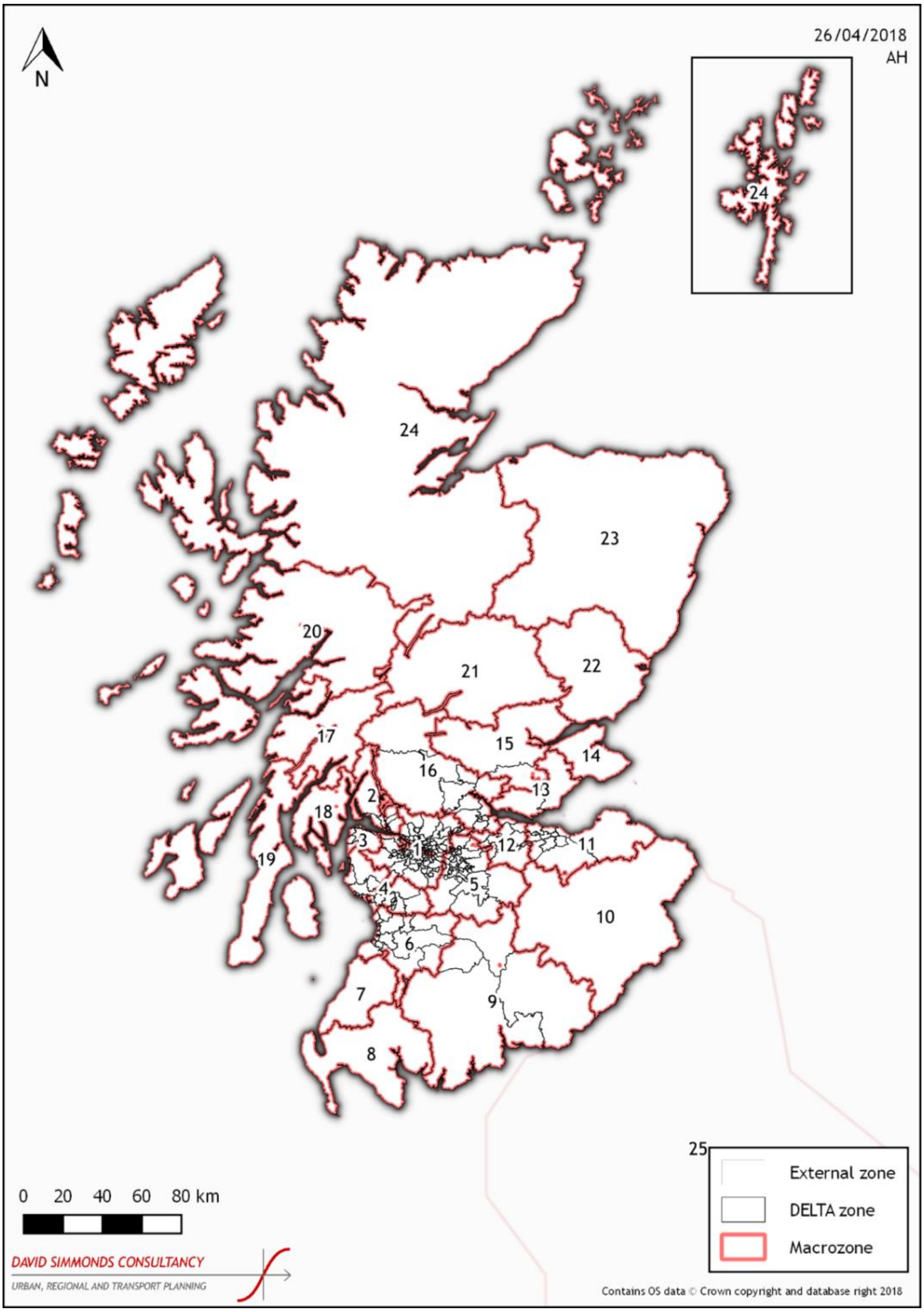

Figure 4 SITLUM model geography

2.2 Model structure

As shown in Figure 3, SITLUM follows a 'time-marching' model sequence. Base land-use data is taken from various sources and fed into the transport and land-use components of SITLUM. A reference case is put together which, in brief, comprises the *base-year database*, upon which calibrated model processes are applied to reproduce a *scenario*, in light of *real planning* and *transport policies*. This constitutes the 'business-as-usual' case: the land-use and transport components of the model work together so that forecast year databases can be produced, given an expected scenario.
The base year for SITLUM14 is 2014. The starting land-use database quantifying the 2014 situation was developed using data from the 2011 Census of Population and households as far as possible, with data from additional sources, including NRS mid-year estimates, for variables outside the scope of the Census.

The model starts from a database representing observations or estimates of the base-year situation, and forecasts a new database containing the same variables at the same level or detail for each forecast year. There can be long time lags within the model dynamics; after the first few years, most of the data inputs to any given module are themselves forecasts produced as outputs in previous model years.

To test new schemes, policies (transport and/or land-use) are applied within SITLUM. Using the reference case as a comparator, it is possible to appraise the impact of the policy/ies.

2.3 The STM (Strategic Transport Model) transport component

The transport model included within the SITLUM package is the STM (Strategic Transport Model), developed by TRL. STM predicts forecast travel demand in terms of trip matrices under policy and planning scenario assumptions. It includes car, bus, rail, cycle and walk modes, across three time periods representing an average weekday, over multiple home-based and non-home-based purposes, and three car-ownership levels. Freight is fixed exogenously and added to the road network to impact congestion.

The model works by taking base-year inputs of trip demand and working incrementally forward from this point. The base year is formed from planning data from the DELTA land-use component (population and floorspace), along with 2011 Census journey-to-work data, attractions from NTEMv7, highway skims from SATURN and TMfS14 (Transport Model for Scotland) PT costs.

In order for runtime to be optimised, the model works on a zonal basis, with an underlying SATURN network with fixed route assignment. Transport choices are made based on the change in generalised cost (GC) compared to the base. Generalised cost within SITLUM is a combination of money costs (enumerated in minutes using WebTAG-based VOTs) – parking, fuel, cordon charges and fares; and time costs – including access, egress, park search and journey times. For public transport, GC includes factors allowing for bus and rail crowding. The components outlined here are modified in forecasts based on policy levers available to the user (outlined in section 3).

As mentioned, highway assignment is fixed exogenously using a SATURN assignment model. Routes and links are determined exogenously, then travel times are determined endogenously using speed-flow equations which vary depending on road type. For rail routing, assignment is also carried out exogenously, using a shortest-path calculation. The subsequent route assignment is manifested within the model, and can be modified by the user (detailed further in the next section).

Parking is modelled in detail – including both capacity limitations as well as the cost and duration. A number of parking zones (predominantly in areas of already-high density or existing parking control zones) are included in the model. Outside these parking zones, a more simple process is modelled: parkers are subject to a tariff based on assumed duration of stay, depending on the purpose of travel. The inclusion of specific parking zones, with capacity and charging calculations, and a second tier of simpler parking calculations allows for a quicker runtime (given the tendency for oscillations when reaching equilibrium for the former).

To model travel choice, SITLUM uses a hierarchical nested logit model involving both mode and destination choice. To maintain efficiency, time period choice is not used. For all non-home-based purposes, the model uses a hierarchy 2 setup, where decisions are made thus: Main mode (PT or highway) feeds into sub-mode (car, rail, subway, bus) from the production zone, and then this is distributed among attraction zones. The exception is for home-based work and education trips: for these, DELTA determines the distribution of trips between home and work zones, and mode choice is distributed according to this.

Once the transport model has produced generalised cost matrices, they are fed into the first post-transport model module, of the land-use component (DELTA, developed by DSC).

2.4 The DELTA land-use component

The first stage of a DELTA land-use forecast is to calculate accessibility using the accessibility module. This takes the most recent generalised costs supplied by the STM, and the most current pattern of land-uses (e.g. disaggregations of households and employment) from DELTA and calculates measures of accessibility for each activity. These measure how difficult it is (in generalised cost units) for households to reach the range of destinations they are likely to require, or for businesses to be reached by the range of people and firms (workers, suppliers, clients) who are likely to need or reach them.

Developer choices are represented by models of how much floorspace to build, and where to build it. Developers' decisions are driven by expected profits, which in turn are driven by occupier demand: development therefore tends to follow businesses and households, whilst also being constrained by the inputs representing planning policy (which control the amount of building which can take place in any location at any time). The development model simulates these developers' actions and has three main components of change which are demolitions, exogenous developments (developments which will happen or are input for 'what-if' tests, specified by the user), and permissible development - development forecast by the model as occurring in response to the economic conditions and planning policy.

The investment, trade and production components are used in SITLUM to model the economy of Scotland. The investment model forecast capacities that influence production by sector in response to changes in wider accessibility, rents and changes to local incomes and population demands. Business activity is measured mainly in terms of employment that are needed to produce the amounts of goods and services forecast by the production model. National growth in employment (and the associated growth in production) is controlled to a given scenario NTEM7. Use of SITLUM is concerned with how transport and land use interventions will affect the distribution of economic activity within Scotland and does not allow the totals to vary. Within each run of the model, the location of employment is determined through processes which represent business choices about

- where within Scotland to invest;
- where to trade and to produce; and
- at a more local level, about where to locate premises.

The income component calculates expected incomes based on household type and the previous number of workers per household, for each household type in each zone. The incomes calculated are estimates of net household incomes after tax, National Insurance contributions and money benefits.

The car-ownership component forecasts the proportions of households of each type, in each zone, which will own a car or cars. Growth in real incomes is usually the main driver of growth in car ownership, but other variables are also considered; in a no-growth situation, growth in car ownership may stop or decline.

The household location component assigns mobile households to zones. The key influences on location choice are availability of housing, cost of location, accessibility, housing quality, and environment. The cost of location is determined mainly by the rent in each zone, which the household location component adjusts to balance supply and demand, up to a certain equilibrium point.

The employment location model is similar to the household location model. It assigns employment (jobs) to zones and forecasts the changes in the rent and occupancy of employment floorspace. The key influences on location choice are accessibility, availability of commercial floorspace and the cost of location.

The employment status component has three main functions. It calculates the forecast employment and categorises these into the applicable socio-economic level. The adjustment of labour supply to meet labour demand is worked out in this component. The other non-adult working age groups (children and retired) are also computed at this stage of the model. Based on all of these newly forecast activities, newly estimated travel to work matrices are derived. These form part of the next transport model run.

The processes described above, in one way or the other, influence each other to produce a set of forecast planning data: numbers of households and people that live in these households; their car ownership; and their status. In addition, the model produces output data containing the location of employment activity; its type; and how much of which type of floorspace it occupies (be it, for example, office floorspace, or warehousing). All of this is packaged together and sent to the transport model, which goes back to the beginning of the progress in the next transport model year.

2.5 Reference model inputs

The reference model represents the 'business-as-usual' scenario. Fixed scenarios for the fully-modelled area are input, with some additional employment constraints for the Glasgow and Clyde Valley area. As mentioned previously, the model is useful specifically for forecasting the spatio-temporal distribution of the scenario.

The economic scenario represents the overall context of the economy within the model. In SITLUM model, this is implemented at two geographic levels. Firstly, at the Scotland-wide level, where the model has been calibrated to be consistent with NTEM forecasts. At the Glasgow and Clyde Valley area the scenario is set to match forecasts from Oxford Economics. The regional scenario is set to change in response to accessibility and planning policy-constrained development.

In SITLUM, the economic forecasts are output from a Regional Economic Model (REM). The REM forecasts the amount of production that is needed to meet intermediate and final demand. The change in production drives the change in labour force (employment) taking into account the effects of productivity change.

The demographic scenario for SITLUM14 is based on the National Records of Scotland's (NRS) Household Projections for Scotland (2012 based) and the NRS Projected Population of Scotland (2012 based). The model has been calibrated so that at the Scotland level, demographic growth is consistent with the independent forecasts.

The location and mix of households and residents change over time through

- migration (longer-distance moves, particularly influenced by employment prospects);
- local moves (particularly influenced by housing availability, but also by accessibility to work and services); and
- gaining or losing employment.

Alongside the *base* and *scenario* inputs, the reference model contains a standard set of land-use policy inputs. These land-use policy inputs inform the modelling of floorspace development, which in turn impacts key land-use indicators. The inputs used in SITLUM are based upon information provided, though the LATIS framework, by the 32 local planning authorities and 2 national park authorities in Scotland. They describe the scale, location and nature of planned development over the entire forecast period. The information modelled includes:

- Sites with planning permission for development;
- Allocations in local plan documents;
- Other sites that were likely to come forward and be made available for development during the period to 2041; and
- Sites where demolition of existing land use was expected.

Knowing what is forecast if business continues as usual, and if what is planned goes ahead, the model can be used to inform policies and their impacts on the wider region as a whole. The next section discusses how exactly this is done in the context of SITLUM.

3 Using SITLUM for appraisal

3.1 Context

Figure 5 shows, at a glance, the forecast zonal change in households within the mainland SPT region by 2041.

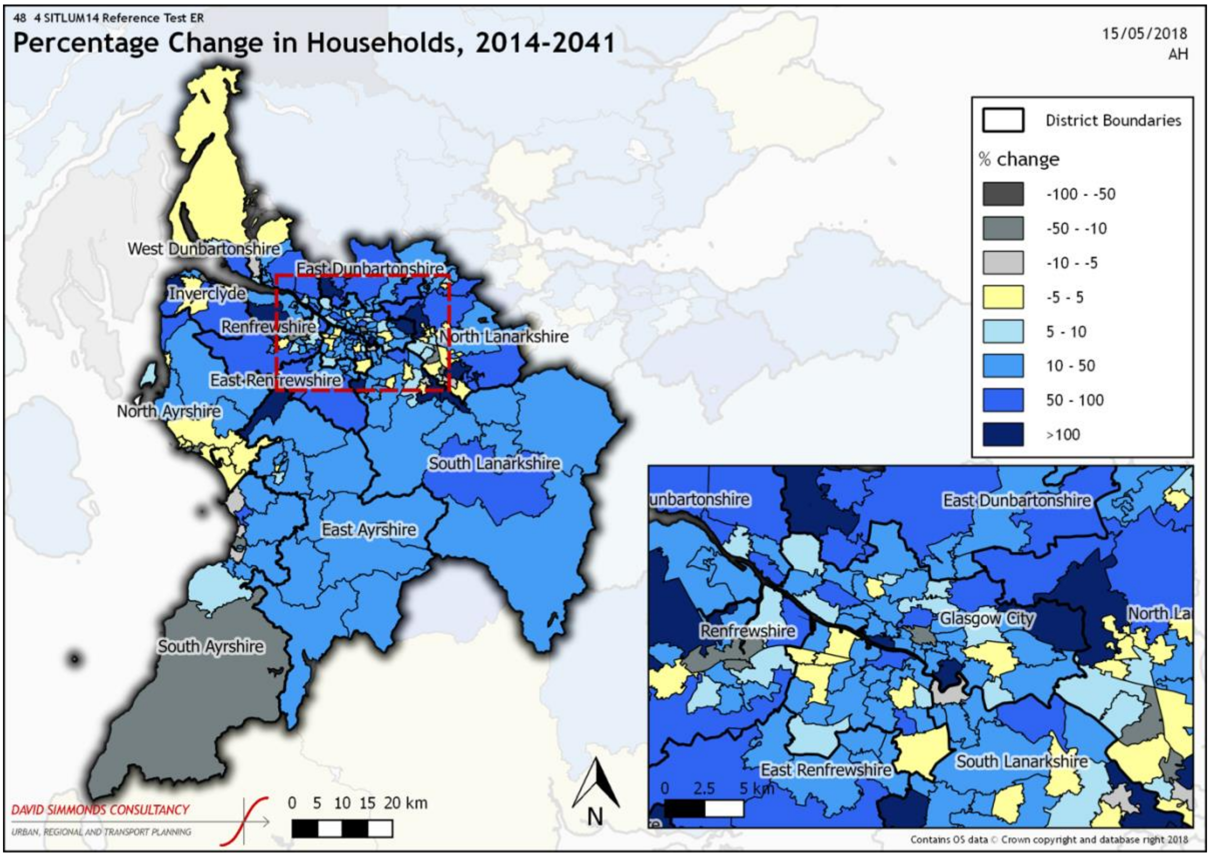

Figure 5 Change in households within SPT region, 2014 to 2041

While it is beyond the scope of this paper to go into detail about the reference SITLUM model, some points are raised which are worthy of note. First, the figure shows the complex mix of outcomes over different spatial scales over the forecast period. It highlights possible trends at the rural-urban fringe, where smaller settlements are growing at the edges and outside the Glasgow conurbation. It shows where we might expect only moderate growth, or even contraction, over time, next to where we might see *considerable* growth.

Of course, the total number of households is only a lone variable in a sea of other potential data points. For example, SITLUM can show how the makeup of individual households varies over time (see Figure 6). Not only are there many more households within the region, there are also significant increases in the number of households with older or retired adults.

Looking to Figure 7, we also see a representation of the increase in demand (in terms of passenger kilometres) for different transport modes, across all time periods. This can be disaggregated by purpose, time period (AM, IP or PM) and car-ownership. SITLUM also allows for distinction between inbound and outbound journeys.

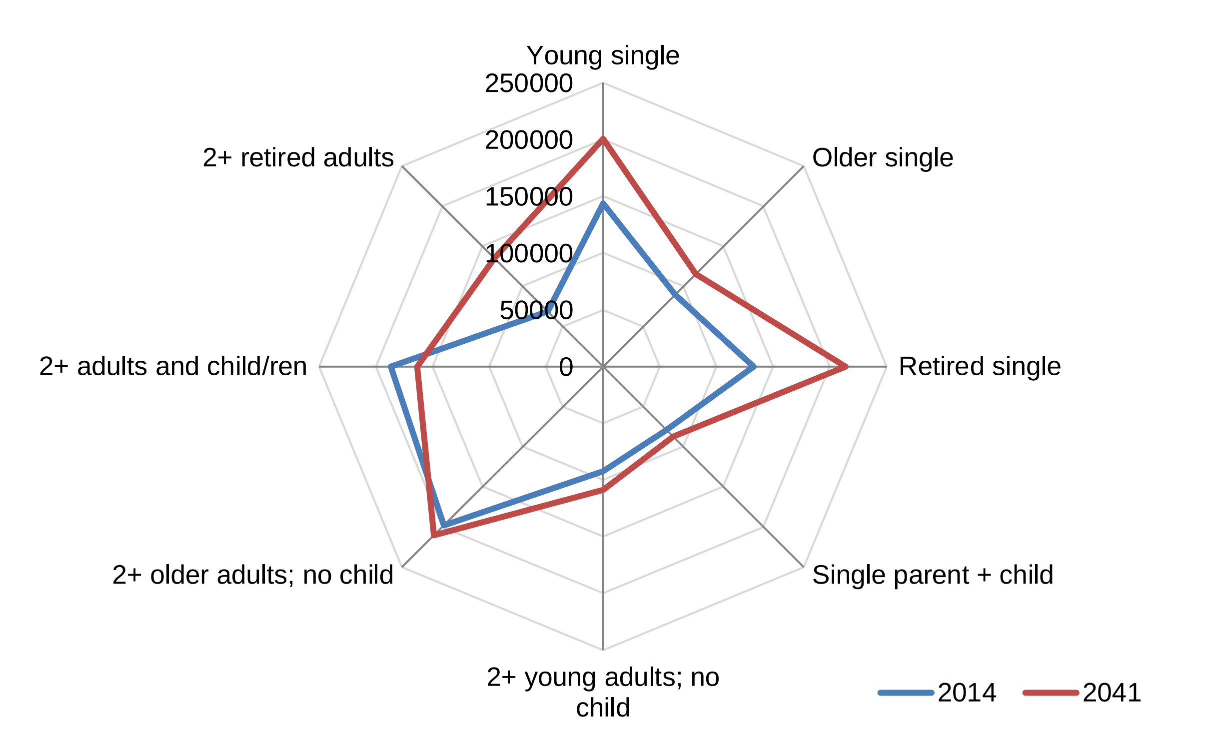

Figure 6 Household composition in SPT region, 2014 vs. 2041

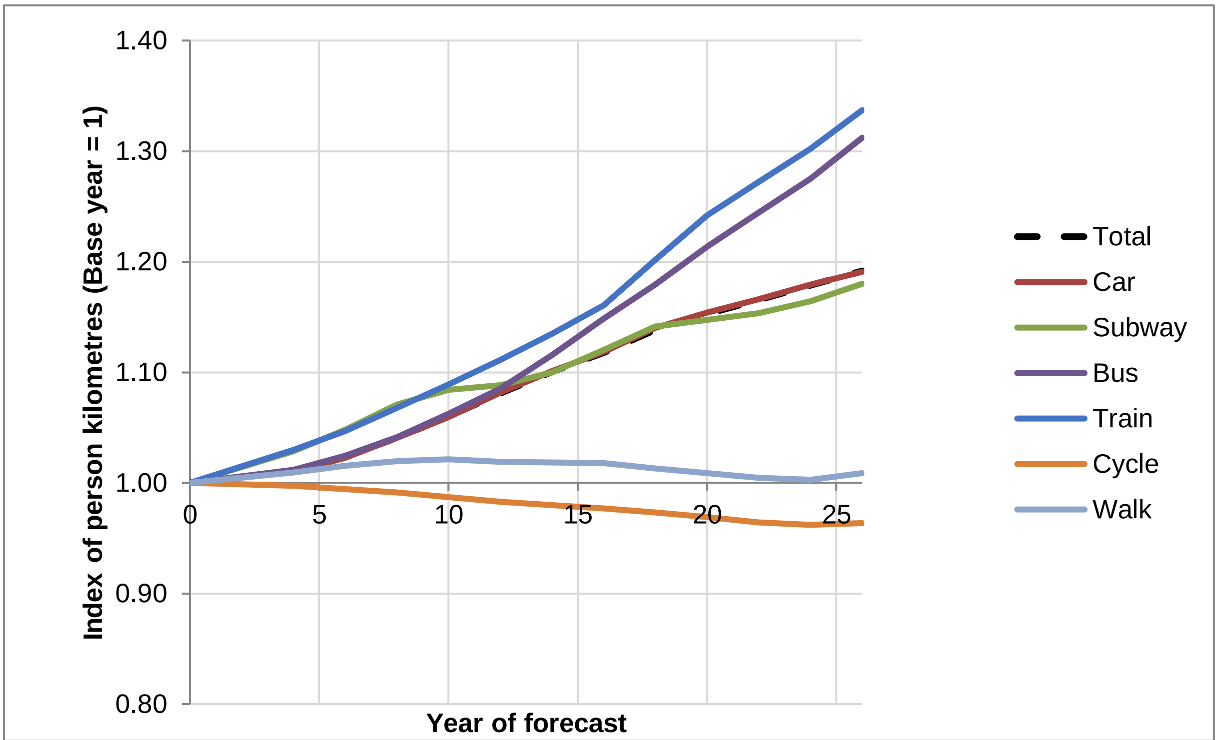

Figure 7 Index of person kilometres travelled by mode in SPT region over forecast

The above figures show some of the ways outputs from the model can be represented; below is a list of some more of the outputs available from SITLUM.

Land-use model outputs:

- Demographic: households by makeup, population by age and socio-economic status, car ownership;
- Economic: employees, workers vs. non-workers, employment by economic activity/sector;
- Floorspace: permitted development, development undertaken, demolitions, rent by floorspace type, floorspace left vacant, total floorspace used, occupied density of floorspace;
- Activity: zonal accessibility, production capacity, total production, cost of freight etc.

Transport model outputs:

- Demand: trip starts, trip ends, person km;
- Time/distance: average travel time, average trip distance, average trip speed;
- Emissions: CO, NO_x, HC, PM10, CO_2.

Transport model outputs can all be expressed by individual mode and purpose, by time period and outward, return or both directions. All of the outputs mentioned can be output at the zonal level; further disaggregations are made for some variables to be used as inputs for the SRTM.

3.2 Policy appraisal: land-use

One of the two main policy appraisal options within SITLUM is controlled by land-use policy levers. There are then two further branches of land-use intervention: pure 'planning' interventions, dealing with development and redevelopment of floorspace; and rejuvenation, regeneration, public realm and infrastructure policies. This section aims to identify the specific policy levers – in practice, real-world packages of schemes are modelled using several combinations of these levers.

The model works in terms of floorspace – expressed in m^2 – and for each unit of floorspace, there is an associated rent, in £/wk. The rent rates serve as actual, representative rents, and serve as a proxy for equivalent costs like lease and mortgage payments. As mentioned in section 2, the floorspace development module works by identifying possible areas of development and testing their viability. This feeds into the employment/household location module and has implications for land-use (and, necessarily, transport demand) across the study area.

SITLUM is capable of modelling three different variations on land-use policy. The first allows for floorspace to be input as permissible – representative of potential planning allocations and permissions. This enables planners to ask the questions:

- *If additional floorspace is allowed in location* x*, how much supply will be taken up?*
- *What are the wider implications on house prices (rents) and densities of occupation?*
- *How can extra planning permission positively impact the wider region?*

This line of questioning lends itself specifically to the appraisal of local plan Core Strategies – an integral part of the local planning framework. The zonal structure of the model is also an advantage here, where more general strategies are the aim, rather than specific, site-level foci – though site-level policies can be deployed. An exemplar of this sort of policy is described later in this section.

A second variation on land-use policy enables floorspace to be built directly within the model, bypassing profitability constraints. This works by forcing an input amount of floorspace to be developed, but not forcing it to be filled. It enables the user to focus on policies of regeneration and redevelopment: *if floorspace in location x is regenerated, what is the impact on the wider region? If we redevelop the land in a given area, what are the wider implications?*

A third variation allows for 'worst-case scenario' inputs. Here, we can approximate a total number of jobs or households expected to occupy a given amount of floorspace. The model calculates the amount of floorspace needed for this activity, and the implications of this are carried into the forecast. It enables the user to answer the question: *if we build* n *amount of floorspace at location* x*, with expected employment* w*, what are the impacts on the transport network?* This use case specifically allows for worst-case-scenario assessments of impact on the wider transport network.

In modelling regeneration, public realm or infrastructure policies, there are further policy levers available. Fundamentally, this would be expressed in changes to accessibility, though investment and other economic changes can be made as well. Atop these, transport interventions can be tested to alleviate issues.

3.3 Policy appraisal: transport

SITLUM has the capability of modelling four immediate, user-facing types of transport intervention. Parking policies, road charging policies, public transport policies, and new station/mode interventions. Additionally, road network changes can be made using SATURN, exogenously to the model.

Parking policies can be applied to the parking zones specified within the parking module. These are areas of high-density urbanity, or existing parking control zones. The model principally takes inputs of changes to overall supply, and charges by period. Changes to supply directly impact the portion of generalised cost attributed to searching for parking; changes to charges directly impact the overall money cost of car travel. Any changes that are made are applied to the base year data – this is split according to private non-residential, long-term, short-term, paid and free parking.

Road charging policies can be applied in two different ways: as cordon charges (ideal for modelling Low Emissions Zone proposals) where those travelling into/out of/through a specified region are charged a flat rate; and as road user charges, where any car user whose journey traverses the region is charged at a set rate per km. Note, that it is possible to model private car users and taxi users separately, in the event that, for example, a LEZ phasing might exclude taxi travel.

Public transport policies can be input in several ways. All PT modes are covered, so the same general rules can be applied to bus, train and subway journeys; these policy levers can be applied both regionally and zonally, and for any or all of the three time periods modelled. The user can apply the following changes:

- Fares: percentage change from the base-year input;
- Service level: percentage change in waiting time from the base-year input;
- Capacity: percentage change in occupancy level of the chosen PT mode – this mitigates changes in perceived journey time coming about because of overcrowding due to increased mode share;
- Speed: percentage change in speed from origin to destination from base-year input – as speed increases, the journey time portion of generalised cost decreases. *NB this is not available for subway journeys*;
- Quality: percentage change in overall generalised cost of travel using the specified PT mode – this can be used to indicate that *overall quality* of travel has improved, in all aspects of the generalised cost;
- Journey time: absolute change in journey time for all origin to destination journeys in the specified zone or region.

New stations can be added to the existing rail network, as intermediate stations (on existing lines between existing stations) or as new branch lines (extending the railway line beyond a station or creating a new branch from a station). Catchment areas surrounding the new station can be set up – so that, for example, one might want to constrain journeys from new stations to start only from within the station's own zone. SITLUM outputs as standard the trip rates for new stations, and the impacts affect the outcome of the rest of the model.

Two new-mode options are available within SITLUM: park and ride and LRT (light rapid transit). When any new mode is input to SITLUM, the model allows for direct competition between it and the existing modes. LRT is input as links between zones within the model, and has levers for:

- Origin of link;
- Destination of link;
- Patronage: percentage uptake of link – e.g. 20% = 1 in 5 users travelling from zone *i* to zone *j* using new mode;
- Fare;
- Wait time;
- Access time.

The LRT option is high-level and does not offer the same functionality as a fully-fledged light rail network. However, it provides a quick, useful way of demonstrating possible effects of LRT between distinct urban centres, or between mixed rural and urban settlements.

The park and ride option allows the linking of a 'park' zone to an urban centre, allowing for multi-modal journeys, by car then PT. SITLUM allows for granular control of the new mode – for instance, allowing for en-route alighting, control over fares, parking capacity and charges (similar to the parking supply model), and control over the bias of demand between local and non-local users.

The detailed policy options in SITLUM allow not only for straightforward variant testing, but also for the appraisal of complex packages of schemes. Any number of combinations of schemes can be tested, and, owing to the relatively short runtime of the model, can be effectively sifted and assessed.

4 Applications of SITLUM: strategy & scheme development and appraisal

4.1 Uses of SITLUM

The relatively short run time for SITLUM enables many more scenarios to be tested than is the case with conventional network models, particularly covering the large area of Strathclyde with a dense provision of transport network and services, aligned with a large population in the Glasgow conurbation.

This model enables analyses and illustration of the forecast growth and resulting travel demand which is largely driven by planning data, combined with likely or committed network provision. The other key benefit of the model is the ability to test a range of options and to carry out extensive sensitivity testing in relatively short timescale and to use this to determine those policies or interventions that are likely to have the greatest or least effect.

This also provides the ability to carry out testing of combinations of options much more easily providing valuable information to decision makers as to how to proceed, or otherwise.

The wide range of outputs is available over a 30-year horizon and it is easy to track how particular elements change, ranging from migration to emissions, numbers of journeys to influences of fares structures, or changes in land-use or travel to modal shift change over the period.

It is possible with SITLUM to examine how intervention options may contribute to desired outcomes. The model on the other hand can often draw attention to other unexpected and undesirable outcomes.

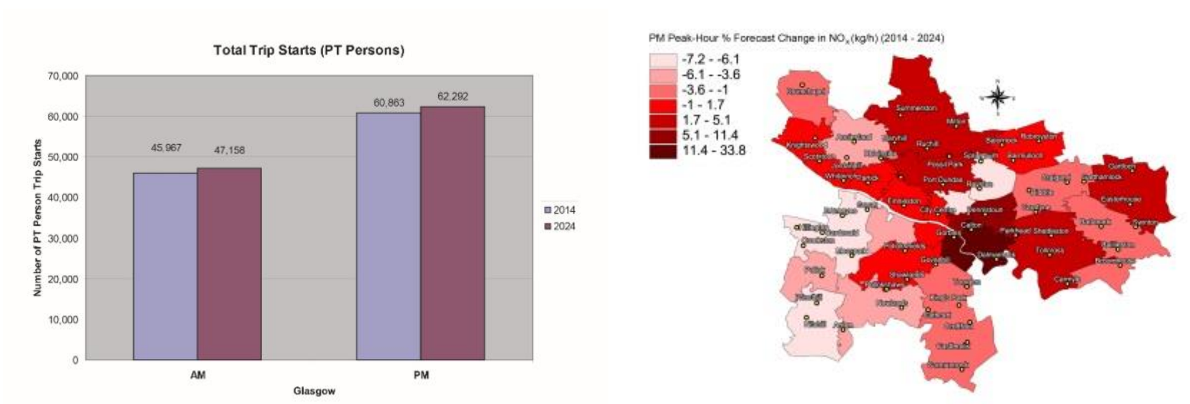

Figure 8 Further examples of SITLUM output

4.2 Previous uses of SITLUM

SITLUM has been used both to aid understanding of the inter-relationships of the range of factors that affect land-use and transport and to assist in option testing of policies that then directs more detailed modelling using other model platforms of those interventions likely to have the desired outcome, or avoid those with an undesired outcome.

As a tool to aid land-use planners SPT has previously provided forecasts of land-use and transport for its constituent Councils to assist development of Local Plans and Local Transport Strategies – for example the model can show the results based on the planned land-use and known or committed transport interventions and can be run to provide alternative scenarios. This can be used as a basis for developing a new plan.

The model was developed in partnership with the Clydeplan (and its predecessor organisations) specifically with regional planning and transport in mind and has been used to provide guidance for decision-making.

SITLUM was a key component used in the early testing and development stages of City Deal; resulting in £1.13bn of infrastructure funding being secured for the Glasgow City Region announced in 2014.

4.3 Planned uses of SITLUM

A key piece of work about to commence is the development of the new Regional Transport Strategy for the SPT area. SITLUM will be used to map the current forecasts as part of the pre-appraisal and evidence gathering element of the work. The model will then be used to test the options generated to develop the new strategy and delivery plan. It will be used to test individual options or combinations and to carry out sensitivity tests on the level of change or combinations of option packages that will deliver the strategy objectives.

Flowing from the strategy there will be an on-going requirement to develop projects identified in the delivery plan and again the model will be used to examine individual options, variations and options packages to assist in decision making towards the right solutions.

With ever-greater focus being place upon tackling congestion and reducing emissions, such as through NLEF and the Glasgow LEZ, SITLUM has a role to play in the testing of policy options designed to meet national and local targets.

5 Conclusion

5.1 Limitations

Being a strategic transport and land-use model, which eschews some amount of complexity and spatial detail to enable fast run times, there are some limitations to the use of SITLUM. Some of these have been mentioned briefly throughout this paper.

First, the lack of an endogenous highways assignment model. SITLUM assumes fixed route assignment for highway journeys, meaning there are no endogenous changes to routes, to by-pass areas of congestion. In terms of land uses, this is somewhat alleviated by the decision hierarchy included in the mode-choice logit model – competition between modes means alternatives are always sought and dynamicity maintained, rather than the model being loaded entirely with ever-increasing congestion. Where viable alternatives don't exist, however, there is potential for misrepresentation specifically of land-use impacts.

Second, there is a lack of fine spatial detail, which means SITLUM is not capable of reliably modelling very small-scale schemes. Examples would be single changes to individual junctions: it may be difficult to confidently differentiate between those changes brought about by oscillation during model convergence, and actual impacts of the scheme. The model is, however, deterministic – meaning that a test case will always return the same result when repeated, provided its inputs do not change.

Third, specific changes to the highway network require the re-generation of the SATURN assignment model. This has implications for the effectiveness of running multiple variations of a given scheme or package. The model has been designed to alleviate this issue, through the ability to implement zonal changes to generalised costs – although the effect of these changes cannot be assessed within the transport model.

Despite these limitations, SITLUM remains a useful tool to be used in the planning process.

5.2 Summary

The need for a multi-tiered strategic transport and land-use modelling in Strathclyde has been highlighted, and in response to planners' needs, a model has been built which addresses this. SITLUM is a fully-integrated land-use and transport interaction model, developed to be highly strategic in its execution. To this end it forms an integral part of the planning process, having been used for numerous regeneration and infrastructure projects in the past. The latest update to SITLUM will initially be used to inform work on SPT's Regional Transport Strategy alongside its readiness for application in helping the region cope with changing demands over the years to come.