THE CONTINUING ROLE OF THE STRATHCLYDE TRANSPORTATION AND LAND-USE MODEL IN STRATEGIC PLANNING

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1 INTRODUCTION

For a number of years Strathclyde Partnership for Transport (SPT) have used TRL's Strategic Transport Model (STM) as a "policy filter", as part of their strategic modelling capability. STM is used in conjunction with a large scale network model, the Strathclyde Integrated Transport Model (SITM) which can provide detailed assignments of vehicle and passenger flows to highway and public transport networks. The same STM has also been used by the Structure Plan Teams in Glasgow and Clyde Valley and in Ayrshire to assist policy formulation. To extend their modelling capability to include the mutual interaction of land-use and transport processes, SPT commissioned TRL and David Simmonds Consultancy (DSC) in 2003 to design and implement the Strathclyde Integrated Transport and Land-Use Model (SITLUM). This integrated the state-of-the-art DELTA land-use/economic model with an enhanced version of the STM.

This paper describes major developments to SITLUM in the past year which have enhanced SPT's ability to model the impact of land-use and transportation policies on travel and land-use patterns within Strathclyde. The model developments have focused on two main objectives:

- to improve the degree of integration of SITLUM and the SITM in relation to land-use and transport interactions;

- to ensure that SITLUM as far as possible reflects the current best practice for variable demand modelling.

The bulk of the paper describes the work of the past year to meet these objectives. The paper also includes a discussion (Section 5) of a method to investigate and rank a large number of potential Park and Ride (P&R) sites efficiently using the model. The focus of the paper is mainly on the transport model and its role as this is where the major changes in SITLUM have taken place.

Before considering the new enhancements to SITLUM it is useful to review how SITLUM works and what its current role is within SPT's modelling framework. This is taken up in Sections 2 and 3.

2 THE PRE-ENHANCEMENT SITLUM MODELLING SYSTEM

2.1 Spatial coverage of SITLUM

STM and DELTA model the patterns of travel and of land use in a “study area” by dividing it into a number of areas called zones whose size and shape are chosen to provide the desired level of spatial resolution for outputs as well as being convenient for estimating zonal population, employment and job levels. An STM study area usually has a relatively small number of zones when compared with large assignment models. SITLUM’s zonal system (common to STM and DELTA) covers the whole of Scotland with 171 zones in order to model the Strathclyde/Ayrshire area (where the zones are concentrated) but taking into account long-distance movements and transport / land-use effects. The transport model, STM, also includes 2 external zones, for England and for Ireland.

2.2 The SITLUM transport model: STM

The STM component, which can also function as a “stand-alone” model, was designed as a rapid analysis desktop tool for transportation and land-use planners. It models travellers’ responses to transport policies (public transport fares and supply, parking etc) and changes in congestion and public transport crowding in specified land-use scenarios (demography, jobs etc). The latter can be provided as exogenous projections from a base or, as here, defined by inputs from a land-use model. The user can apply a range of transport policy levers over modelled forecast years, as well as explore the implications of scenario changes in terms of demography and car ownership, real earnings and fuel prices.

STM models travel in terms of different trip purposes (work, shopping etc), modes of travel (car, bus, rail, subway, walk cycle), time of day (AM peak period and Inter-peak period in the pre-enhancement version) and traveller’s household car ownership (a measure of car availability). In essence, STM takes a base matrix (for 2001) of travel patterns and travel costs and predicts corresponding forecast matrices in a specified set of future years. Travel costs are determined principally by policies (e.g. for fares) and congestion effects. Journey times, for example, have been modelled (pre-enhancement) using zonal speed/flow relations and simplified assumptions about the routing of traffic.

2.3 The SITLUM land-use model: DELTA

The DELTA package has been developed by DSC since 1995 (see Aramu et al., 2006, and other papers at *davidsimmonds.com*). It allows a range of models of land-use change to be implemented for any city or region. The models can focus on change within one city, across a region or group of regions, or on a combination of both levels.

DELTA is designed to interact with any appropriate transport model in order to create a full model of interactions between land-use, economy and transport. Because land uses and economic activities take time to change, these interactions are modelled over time, taken into account time-lag effects, as illustrated in Figure 1. DELTA provides land-use or economic inputs to the transport model, which generate demands for transport. The transport model provides measures of accessibility and environment to DELTA, which can influence the location of households, employment and economic activity.

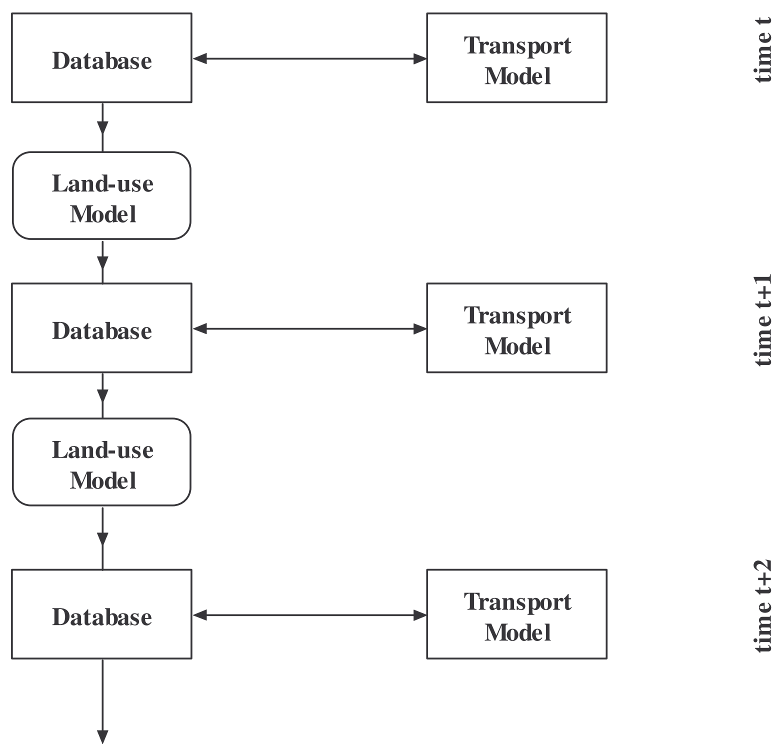

Figure 1: Flowchart of run sequences in land-use/transportation system

2.4 The structure of SITLUM

STM and DELTA exist within the SITLUM modelling system as separate component programs. STM and DELTA run in a pre-defined sequence over the range of years to be modelled, exchanging data in the process and thus creating mutual interactions between the two models. STM provides DELTA with accessibility (travel costs) and trip data for movements between study area zones; DELTA generates land-use planning data and commute patterns (influenced by travel costs, taking into account time-lag effects) for use in STM. This is illustrated in Figures 1 and 4. The STM currently interacts with DELTA over a 20 year period and provides transport matrices every 2 years based on the redistribution of trips and updated land-use patterns.

After running SITLUM, outputs for the entire sequence of modelled years are available for evaluation, including outputs on congestion, modal shift and emissions from STM and on land-use changes from DELTA. Cost-benefit calculations can also be enabled.

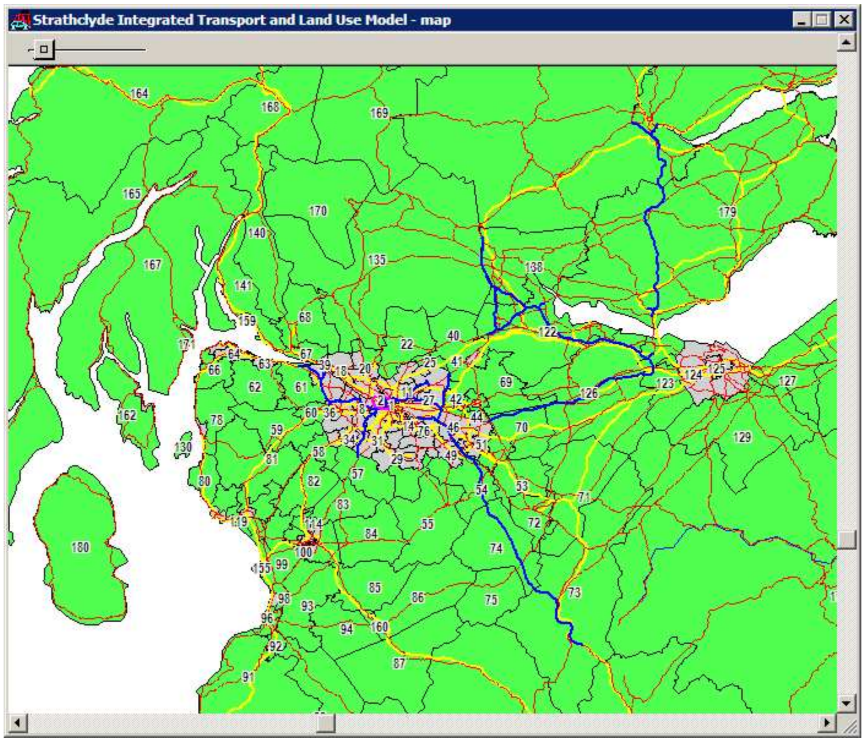

Figure 2: The SITLUM Graphical User Interface

A striking feature of SITLUM is its Graphical User Interface (GUI) program (Figure 2) which enables coordinated runs of STM and DELTA to be set up and resulting model outputs to be displayed graphically. In particular, the GUI has an interactive map which can be used to generate exportable bar charts of policy impacts and GIS-style "thematic" mapping of outputs. The GUI functions as STM's standard interface when STM is used as a "stand -alone" model.

2.5 Example SITLUM results

Figure 3 shows some purely hypothetical land-use impacts arising from introducing a very high quality LRT corridor between two urban centres in 2005 with 7000 new dwellings permitted from 2005 along the corridor. This example was devised for illustrative purposes only and does not represent the policy of SPT or any other party (based on Aramu et al, 2006).

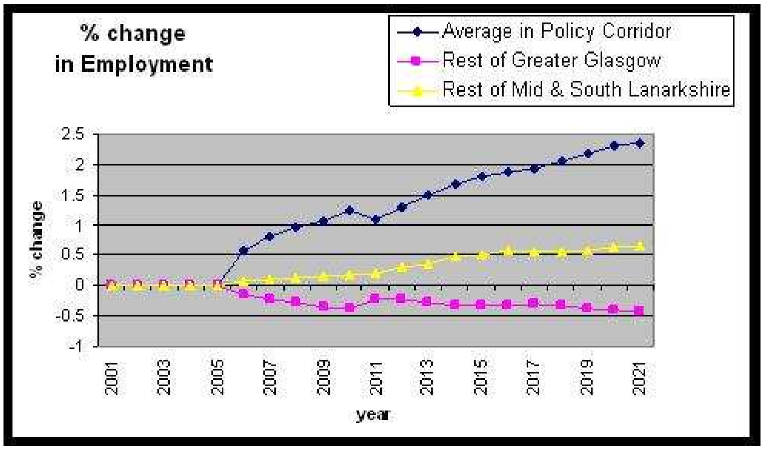

Figure 3a Employment impact in Corridor

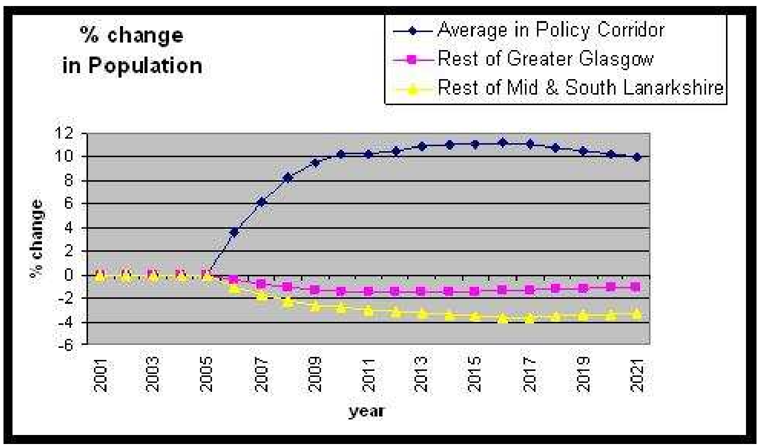

Figure 3b Population impact in Corridor

3 A STRATEGIC MODELLING FRAMEWORK: SITLUM AND SITM

One of the primary responsibilities of the Research Team at SPT is to forecast future demand for transportation and to predict demand changes in response to alternative land-use and transportation policies. Prior to the enhancements described in this paper, SPT had the following strategic forecast models available:

- SITLUM (as described in Section 2)
- SITM4

SITM4 (Strathclyde Integrated Transport Model, Version 4) is a large scale strategic transport model with 1059 zones and incorporates models of the AM peak, Inter-peak and PM peak periods for car and public transport. It is not linked to a land-use model (unlike STM in SITLUM) and therefore cannot simulate land-use and transportation interactions; SITM4 uses pre-defined exogenous planning data sets to forecast trip patterns (rather like STM in stand-alone mode). Using the trip patterns forecast by its mode split/redistribution demand models, SITM4 performs detailed link and junction assignment for highway (using SATURN) and public transport (using TRIPS). These assignment procedures allocate interzonal flows to the links of the highway and public transport networks. The public transport assignment model also splits public transport trips into bus, rail and underground components.

A degree of integration of SITLUM and SITM4 has been achieved using a technique in which the growth in flows between SITM4 zones, relative to the base of 2001, is derived from growth between "corresponding" zones used by SITLUM. This procedure (called "growth factoring") generates forecast trip patterns for SITM4 from the base without using the SITM4 demand models. These new trip patterns (for both highway and public transport) can then be assigned to the highway and public transport networks using the SITM4 assignment models.

Put slightly more technically, SITLUM provides growth factors for each zone pair in the SITM4 zonal system; these are calculated from base year and forecast year weighted combinations of the flows for 'corresponding' Origin-Destination (OD) pairs within the SITLUM zone system. A correspondence table gives the STM zones which overlap with each SITM4 zone and a weight factor

The overall design of the "pre-enhancement" modelling framework is illustrated in Figure 4. Only the assignment part of SITM4 is shown (the processes which allow SITM4 to generate its own matrices from a base are excluded).

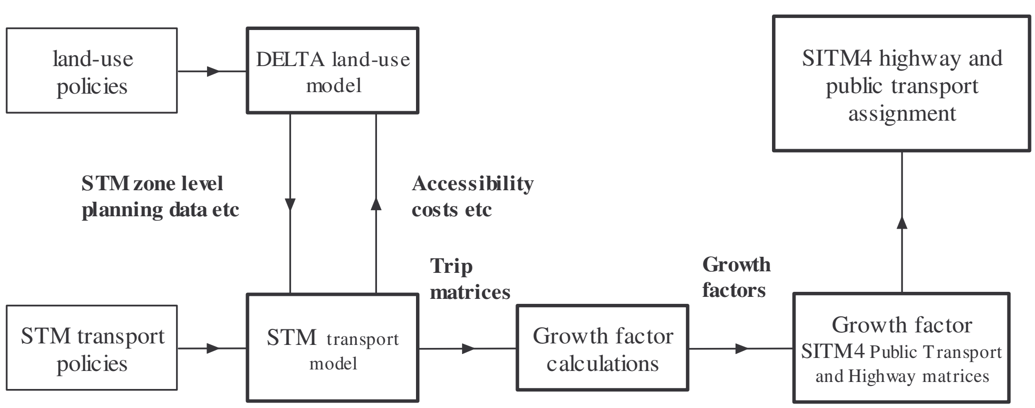

Figure 4: Schematic diagram of the pre-enhancement modelling framework

4 THE ENHANCED MODELLING FRAMEWORK

4.1 Limitations of the old model framework

The existing SITLUM and SITM4 models allow SPT to forecast changes in the future demand for transportation. However, the two modelling systems have different modelling methodologies and different data inputs. Figure 4 shows that the only link between SITLUM and SITM4 was through the 'growth factoring' process (Section 3) which was used to update SITM4 base matrices to the forecast year for assignment to the highway and public transport networks. This procedure avoids using the mode split / redistribution demand models of SITM4 (not shown in Figure 4). There is no link between these latter models and SITLUM (for example, with the land-use calculations in DELTA).

SPT wished to ensure consistency between these models so that at a practical level the models give compatible and equivalent outcomes when the same policy scenarios are run. This would require an appropriate form of integration of the two modelling systems.

SPT also wished to enhance the ability of the STM model to forecast the impact of highway-based policies such as highway construction and road charging. To improve the current approach it would be necessary to replace the current zone-based highway models with a link-based representation based on the network used by SITM4. This improvement would increase the consistency of journey times calculated in STM and SITM4.

SITM4 models transport behaviour in three time periods (AM, Interpeak and PM peak). In contrast the pre-enhancement SITLUM model lacks a PM peak (but assumes symmetry and uses growth in AM traffic for the PM peak when applying growth factors). Integration of SITLUM and SITM4 therefore requires the addition of a PM peak model in STM to achieve the desired degree of integration.

The opportunity was taken to update a number of other elements of the current SITLUM model, especially in relation to the STM strategic transport model so that the model system would show greater conformity with Government guidance on modelling and current transport modelling practice in Scotland.

4.2 Identifying the objectives of the new model framework

SPT initially commissioned a Scoping Study from TRL and DSC on how the integration of SITM4 and SITLUM could be improved and how the forecasting ability of the SITLUM system could be enhanced. The Scoping Study identified a number of key tasks which are now discussed.

Task 1: Growth factoring

The growth factoring technique was too simplistic in the way growth of traffic predicted in SITLUM was applied to the SITM4 travel patterns - "corresponding" SITLUM and SITM4 zone pairs were assumed to have the same growth (see Section 3). A new interface would convert DELTA planning data forecasts (employment, population, jobs etc) from the SITLUM zone system to the SITM4 zone system. These planning estimates would then be used to 'disaggregate' growth for travel between SITLUM zones over SITM4 zone pairs so as to reflect likely changes in land-use changes at SITM4 zone level implied by SITLUM.

Tasks 2–8: Changes within STM

These tasks concerned changes to STM to improve its consistency with SITM4 and to increase STM's conformity to official guidance and standards for variable demand modelling.

2. Introduction of a link-based representation of the highway network – the STM could then run using a network imported from an assignment model (in SITLUM, in SATURN format). STM had previously used routes defined in terms of the zones through which travellers would pass.
3. Replacement of the mixture of link- and area-based speed flow relations, applied at zonal level, by link speed/flow relations for the new link-based network; these would be chosen to maximise compatibility with the SITM4 base year network supply characteristics and would correspond to the SATURN network model being in 'bufferised' form (i.e. without simulation data for junctions).
4. Implementation of a feedback mechanism which transfers routing and transport cost information from SITM4 to SITLUM.
5. Improvements to the STM base travel matrices. This would involve the application of improved trip matrix building techniques to the calculation of the base matrices. In particular, journey times from the assignment calculations would be used in the matrix estimation procedures.
6. Design and implementation of a PM peak model (for the time period 1600-1900) within STM, thus bringing it more into line with SITM4 and increasing STM's forecasting capability.
7. Recalibration of the distribution and mode-choice models within STM.
8. Conversion of STM demand relationships for mode split/redistribution to logit-based models; this form of model has become a de facto standard for transport models; comparison with other transport models is therefore made easier and it also allows STM to make more use of the results of research, which is often based on logit models.

Task 9: Generation of SITM4 format planning data.

An interface would be created which would supply the SITM4 demand models with planning data sets based on forecasts from DELTA in the format required by SITM4. This would enable the full SITM4 model to be run using SITLUM compatible planning data as an alternative to the standard exogenous projections it normally uses.

4.3 The new model framework

Figure 5 shows the new modelling framework in schematic form. In principal the links between the components could be fully “automated” but at present some require a degree of manual intervention. The diagram is not strictly a flowchart but rather serves to show the relationships between the model components.

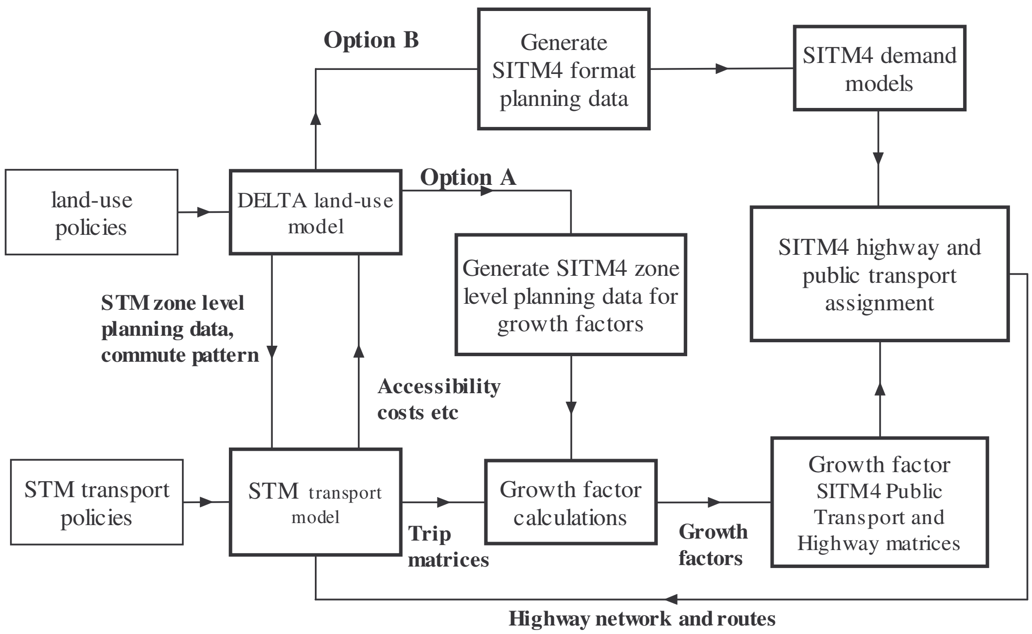

Figure 5: Schematic diagram of the post-enhancement modelling framework

In forecasting over a number of years, DELTA runs every year and STM every two years. Figure 5 shows that there are two optional routes which lead to the use of the SITM4 highway and public transport assignment models in a given forecast year. Under Option A trip matrices from STM and planning data at SITM4 level from DELTA can be used to calculate growth factors for travel between SITM4 zones (Task 1, Section 4.2). The growth factors can then be applied (bottom right, Figure 5) to the base SITM4 matrices; the result can then be assigned using the SITM4 assignment models. Option A is limited to the years in which STM is run.

Option B corresponds to Task 9, in which SITLUM-based planning data is supplied to the full SITM4 model (top right, Figure 5).

The ‘feedback’ link from SITM4 and STM (Task 4) has been implemented as

- the capability of STM to use link-based models for highway congestion based on those in SITM4
- the capability of STM to read in multiple routes for car travellers of different classes (e.g. trip purposes) between each zone pair in SITLUM zone system.

The routing of cars can be calculated by assigning SITLUM level highway trip matrices to the SITM4 network (in bufferised form). This is not shown in Figure 4 but formally may be thought of as being contained in the feedback process. This allows the possibility of routes being recalculated rather quickly when compared with an assignment of the SITM4 matrices using the fully detailed SATURN assignment model. The routing calculations can be updated, if desired, to take into account changing conditions and network structure by re-running the assignment calculation. In addition, it is possible to redefine the supply functions in future years by appropriate rebufferisation of the SITM4 network model. These features of the modelling presuppose Tasks 2 and 3 in Section 4.2.

Pending further development, the new routing facilities do not apply to the public transport movements in STM which are treated in a manner similar to that in the pre-enhancement model. STM does not itself contain an internal assignment model which re-routes travellers as the model runs. A simple form of this mechanism is the subject of a further phase of development. However, when modelling over a number of years, re-routing effects can, to some extent, be represented externally by appropriate updating of the routing pattern as mentioned above.

5 A FURTHER MODEL EXTENSION – MULTIPLE PARK & RIDE MODELLING IN THE NEW MODEL

5.1 The user perspective

Transfer between transport services is an important element of the “seamless journey”. Efficient integration between bus, rail, ferry, Subway and car trips is vital in keeping journey delay to a minimum. A good example of integration in the west of Scotland is Park and Ride, integrating car, rail, and potentially bus trips.

The SPT Park and Ride Action Plan brief requires SPT to develop and implement strategic park and ride facilities across the region.

This version of SITLUM will inform the plan by providing a mechanism to interrogate possible Park and Ride sites within the SPT area. The provision of output from the model such as potential demand at the sites, modal shift, and link performance characteristics on the network, will be some of the key criteria that will be used to determine the suitability of sites for inclusion in the park and ride development programme.

5.2 The modelling challenge

One of the facilities that may be implemented in STM in the near future will allow SPT to carry out rapid assessments of large numbers of park and ride options. The purpose of this and the next section is to give a flavour of the kind of model envisaged and the challenges involved and to illustrate how the new enhanced SITLUM is a springboard for many further developments.

The current park and ride (P&R) model in STM allows the user to obtain an estimate of the utilisation of a new site subject to capacity constraints imposed by the number of car park spaces. It is set up to most effectively represent P&R sites which serve a well-defined urban centre. In order to specify a P&R site in STM the user must use the appropriate policy setup windows in the SITLUM GUI program (Section 2.4). Each site requires a fairly large number of data fields to be entered containing the values of site-specific and more general parameters, a process which is time consuming if many sites are to be considered. The facilities for selecting for modelling P&R sites in various combinations and collating the outputs is also somewhat limited and not especially user friendly. It is therefore clear that a new model facility requires modifications and extensions to the SITLUM GUI program.

A further problem of the current P&R model is connected with the routing and spatial resolution aspects of the model. The current model uses 'zonal' routes to define the route of the P&R and to determine the potential users of the P&R site. The P&R is "located" by the zone which contains it and the urban centre is itself a zone. Potential users of the P&R are those whose car routes to the urban centre pass through the P&R zone. This criterion can be extended to include car travellers whose destinations are intermediate between the P&R zone and the urban centre. The question here is how is the new model is to take into account the link-based highway network and multiple routing in the new SITLUM.

5.3 Possible solution

There are no perfect solutions to all the problems of modelling park and ride in an STM-type model. A pragmatic and practical solution must be sought.

The enhancements to the SITLUM GUI are relatively straightforward because the GUI is flexible and fairly easy to maintain. Here is an example of how the setup routines can be enhanced.

- Allow the user to enter basic site specific data into a file (via excel) (P&R site file)

- Store all none site-specific parameters in a separate file (P&R parameter file). Allow a categorisation of P&R by type and use the type identifier in the P&R site file.
- Create a facility in STM which allows a selection of P&R from the site file as part of the standard "policy folder" creation. A special window would be created which would allow viewing of the details in the site file and selection of P&R.
- Create a spreadsheet style window which allows the viewing of the details selected for the policy. This would be accessible through the policy setup window.
- Create a new window display for showing the results for each P&R at a glance.

This facility will reduce the amount of repetitive data entry and provide flexibility and streamlining in the selection of sites for model runs.

The development of the demand model is more challenging. The simplest modification is to use highway network nodes to specify the location of P&R sites (rather than zones) and their linkage to the network. The potential users of a P&R site will need to be selected on the routes which "pass" close to the P&R (analogous to the criterion in Section 5.2) but taking into account the spread of routes for each zone pair. The model will also be able to represent the diversion of cars to the P&R site by using the routing information input by the new STM. Finally, it will be necessary to use a form of composite P&R to treat the case of multiple P&R sites available to movements between the same zone pair; a similar approach is used in the pre-enhancement version of STM.

6 SUMMARY

This paper has described enhancements to the Strathclyde Integrated Transport and Land-Use Model (SITLUM), which incorporates the TRL Strategic Transport Model (STM) and the DELTA land-use model of David Simmonds Consultancy. The enhancements have focussed on improving the linkages between SITLUM and SITM4, SPT's large scale strategic transport model, and increasing the consistency of the two model systems. The principal changes have concerned:

- The use of land-use forecasts from SITLUM in running the SITM4 demand and assignment components.
- Implementing a link-based network within STM with congestion modelling based on the network model of SITM4 and the possibility of some feedback of data from SITM4 to STM.
- Extending STM's modelling to include a PM peak model.
- Introducing hierarchical logit models for demand into STM and making other changes to increase consistency between STM and SITM4 and to bring STM more closely into line with Government guidance on variable demand modelling.

The paper has noted possibilities for further development and illustrated the possibilities of more innovation using multiple park and ride modelling as an example.

7 BIBLIOGRAPHY

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