The Cardiff Modelling Suite: *Innovative Solutions for a Dynamic City*

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1. Introduction

Since 2008, Cardiff Council has received funding from the Welsh Government to promote the European Capital City as a 'Sustainable Travel City', with a primary objective to force a shift away from private vehicles to more sustainable modes including pedestrians, cyclists and buses.

Over the last four years, Cardiff Council has been delivering this initiative through a wide range of interventions including a pedestrianised High Street, improved cycle infrastructure and enhanced bus priority.

Delivering these interventions has not been without challenges, and the development and application of the innovative *Cardiff Modelling Suite* has been fundamental to overcoming these and making the project a success. At the same time, the work has helped challenge existing modelling techniques and is pioneering new approaches to network management and control.

This brief paper summarises the collaborative work that has been undertaken between AECOM and Cardiff Council to build and apply the Cardiff Modelling Suite. Modelling work includes pedestrian and bus priority, bus station operation, air quality, and VISSIM-SCOOT. The paper explores how the modelling principles could be developed further including methods to implement ensemble modelling (running a large number of scenarios under different flow and parameter combinations) utilising cloud computing.

The paper is laid out as follows. Section 2 presents the Cardiff Modelling Suite and the schemes it has helped implement, whilst Section 3 discusses the VISSIM model in more detail. Section 4 discusses progress on linking the VISSIM model to SCOOT and Section 5 discusses some concepts for ensemble modelling in microsimulation. Section 6 presents the key conclusions.

2. The Cardiff Modelling Suite

Network models are built and applied for four fundamental purposes:

1. To understand network operation;
2. To identify and refine solutions;
3. To provide robust evidence; and
4. To communicate to stakeholders.

In application to Cardiff, a modelling suite was required that could achieve each of these objectives and its structure is shown in Figure 1 below.

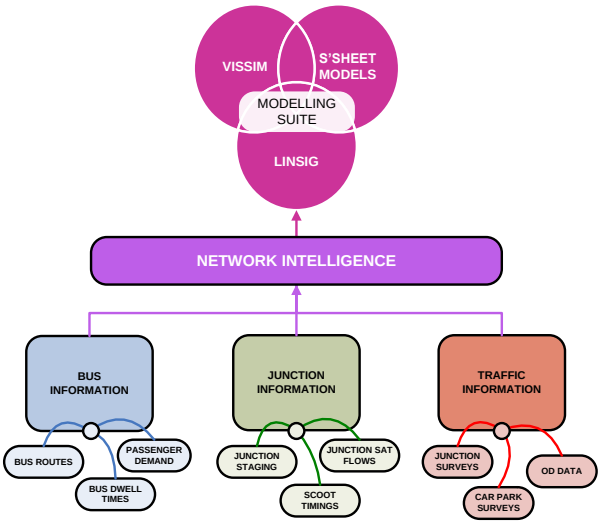

Figure 1: The Cardiff Modelling Suite

The figure shows the modelling suite made up of three fundamental modelling elements:

1. LINSIG models of key nodes/regions;
2. VISSIM microsimulation model of the city centre; and
3. Bespoke spreadsheet models describing network operation.

Supporting these three fundamental modelling elements is a strong base of network intelligence, including information on bus operations, junction information, and traffic information.

Typically LINSIG models are used to test small changes to the network, whilst a VISSIM model is used to test more significant schemes, or where there is a high level of interaction between closely linked junctions and/or where bespoke vehicle operation has a key impact on network operation. The spreadsheet models are used to feed into the LINSIG and VISSIM models and carry out 'higher level' modelling.

The modelling suite has been used to address all four fundamental modelling purposes and has proved to be very successful over the course of the Sustainable Travel City project. Some example schemes the modelling suite has helped to deliver are listed below:

- Bus pre-signals on the main approach to the city centre from the north improving bus journey times and reliability;
- Introduction of various straight across pedestrian crossings improving pedestrian amenity and crossing experience;
- Bus lanes around the city centre providing improved bus journey times and reliability;
- Removal of pre-signals on an internal junction within the city to improve bus journey times and reliability;
- Additional bus stops and bus 'hubs' around the city centre to improve bus passenger amenity; and
- Pedestrianisation of the busy High Street, closing it to through traffic generating greater footfall and improving air quality.

As well as applying the modelling suite to the 'standard' schemes described above, the suite has been used to help inform the current operation and design of a new bus station in the heart of the city centre. This has involved the development of a number of innovative bespoke bus station modelling tools in both VISSIM COM and spreadsheets. The models have been used to help inform the most appropriate bus station design, including layout, the required number of stands, and the benefits of Dynamic Stand Allocation (DSA). This has been particularly important given the high land values in the area. This work is ongoing.

3. VISSIM City Centre Model

Traditionally large city centre microsimulation models pose significant issues to modellers and clients in terms of:

- difficulty to build and validate;
- long runtimes;
- high maintenance costs; and fundamentally
- their poor accuracy on sections of the network under consideration.

The Cardiff VISSIM model is different to this traditional approach. Its scope is shown in Figure 2 below.

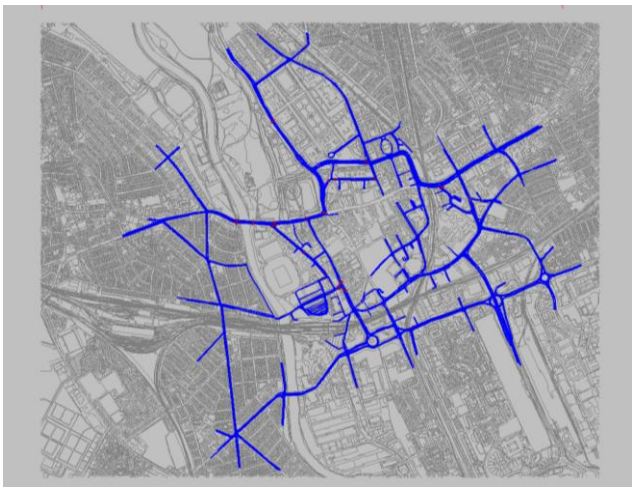

Figure 2: Cardiff VISSIM model

A VISSIM model is maintained of the city centre with bus routes and signal timings in operation across the whole network. However, for each different scheme(s) being considered, a 'cordon' of traffic is modelled in a smaller section of the city centre based on recent surveys. So if a scheme is being considered on the eastern side of the city, traffic on the western side is not modelled and the network is 'empty' except for bus movements in this area. This provides the following benefits over the traditional approach:

- Base models are much easier to validate as they contain fewer vehicles, and critically are more accurate in the network area of interest based on up to date surveys;
- Runtimes are much lower as there are fewer vehicles in the network;
- Consistency is maintained as 'sub models' are derived from a single 'master' model of the whole city centre; and
- Development and maintenance costs are kept to a minimum.

The modelling suite is being used in conjunction with the exhaust emissions model AIRE (Analysis of Instantaneous Road Emissions) to help inform possible solutions on a section of road recently announced as an Air Quality Management Area (AQMA). Given the stop-start nature of traffic in the area, and in particular the long waiting times of buses,

microsimulation is the best model to be used. Possible solutions to improve air quality range from removing through traffic, to changing the coordination of the signals to better expedite traffic through the area.

4. VISSIM-SCOOT

Over the last six months AECOM has been collaborating with Cardiff Council to test the linking of the Cardiff VISSIM model with an offline version of SCOOT.

The benefits of such a tool are significant; in particular given lower investment budgets solutions involving parameter changes come at a much lower cost over 'hard' infrastructure changes.

In the past, network operators have not been able to carry out offline testing of control strategies so the numerous parameters in SCOOT have been left relatively untouched for fear of disrupting well established traffic patterns. The ability to test SCOOT strategies in an offline environment provides greater opportunities for network operators to 'explore' more optimal solutions; in particular, test the influence of more obscure SCOOT parameters and combinations of parameters. Not only will this provide opportunities to further optimise the network, it will provide a much needed practical training tool for network operators.

Following successful linking of the Cardiff VISSIM model to PCSCOOT, which requires little effort, some issues were found with the system. The network modelled contains a number of closely adjacent SCOOT multi nodes and detailed validation of the VISSIM-SCOOT model with Cardiff's SCOOT team identified links within the model that appeared to be over saturated compared to what was expected using local knowledge of the network. Using available CCTV this was confirmed and further investigations identified that on street phase delays were being incorrectly implemented in the interface.

This is clearly an issue and we are awaiting a fix from Siemens before this element of testing can continue. We hope to receive this in September 2012. On receiving the fix we will take the project to the next stage and look to explore a range of SCOOT parameter changes and their impact on network operation.

An interesting concept of linking VISSIM to SCOOT is that signal timings in the VISSIM model change from being a model input to a model output. This is a subtle, albeit significant change to the modelling fundamentals. One of its implications is discussed in the following section.

5. Ensemble Modelling

A traditional modelling approach is to build and validate a base model, calculate future year demand, and determine whether a scheme will 'work' or not in the future year. A number of schemes could be tested, and essentially a 'yes' or 'no' is given as the final output.

However this is not particularly useful to network operators as it tells them little about the conditions under which the scheme could work. A more useful question is 'when will it work' rather than 'will it work'. For example, a network operator may wish to know under what traffic conditions the network will operate, and find ways to ensure that traffic doesn't exceed that critical level. Perhaps through achieving a certain level of modal split, or more aggressive travel plan measures etc.

In order to use models to answer these more difficult questions, multiple model runs need to be carried out across a range of conditions covering different levels of traffic demand. Within a traditional microsimulation model this is difficult as signal timings are usually 'fixed' and taken from a signal optimisation model such as LINSIG. Carrying out many runs in this nature would be very time consuming and costly.

However, being able to run models in SCOOT (and thus signal timings become an output) enables the single model to properly optimise network operation; running multiple models with a computing 'cloud' under different flow conditions is more tractable.

Figure 3 shows a simplistic situation where this has been applied. Traffic demand in two opposing directions has been varied, and the overall network journey time recorded. The 'capacity envelope' describes the range of parameters (in this case flow in the two opposing directions), above / below which the network will / won't operate satisfactorily.

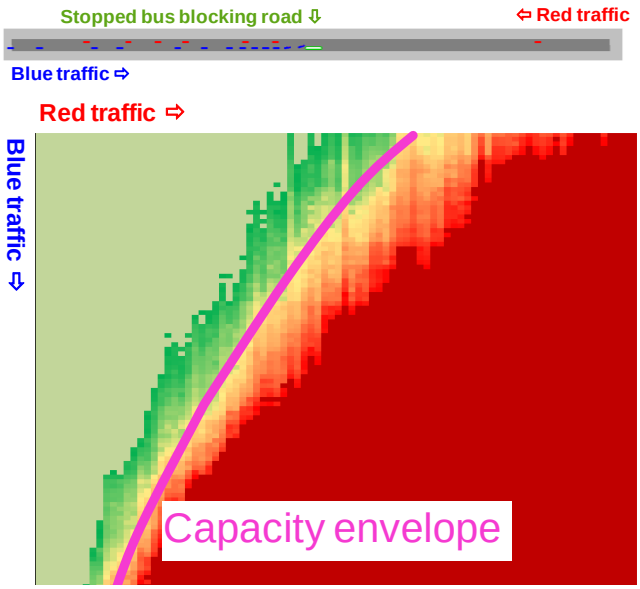

Figure 3: Ensemble modelling output. Green to red shows good/bad network operation.

6. Conclusions

This paper has described some of the more interesting and innovative elements of the Cardiff Modelling Suite and discussed some future applications in terms of VISSIM-SCOOT and ensemble modelling.

In summary the key conclusions are:

- The Cardiff Sustainable Travel City has benefited greatly from the design and implementation of the Cardiff Modelling Suite;
- Utilising a range of modelling platforms and picking the most suitable for the scheme in question provides best value to the client;
- City Centre microsimulation models need not be expensive and difficult to validate;
- When fixed, the VISSIM-SCOOT interface will help deliver cost effective network solutions, and give network operators greater understanding of the network and methods of control; and
- Ensemble modelling, in conjunction with VISSIM-SCOOT, will provide greater information to network operators and help understand the conditions under which networks will and won't operate effectively.