EXTRACTING VALUE FROM A STRATEGIC FOUR-STAGE MODEL

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1 – INTRODUCTION

Strategic transport models are developed by local authorities, transport partnerships and government for a variety of reasons including transport forecasting, scheme appraisal and development planning. However, these models are usually built to meet one objective only - to provide traffic flows and to assess the economic case for a single proposed transport scheme.

Authorities in larger urban areas often maintain an in-house model which will see regular use and which may occasionally be used more diversely. However, most usage is generally limited to forecasting major schemes and developments. For many smaller authorities where major schemes and developments occur infrequently, maintaining a model may not be financially justifiable.

Figure 1: Temporary traffic management at Palmerston Pl / West Maitland St, Edinburgh

It is our belief that many local authorities do not make best use of the modelling tools they have available. They may also not adequately consider the case for the continued maintenance or enhancement of models. There may be a perception amongst decision-makers that transport modelling does not offer value for money. With increasing financial pressures, this can lead to modelling being undertaken only with great reluctance when it is deemed necessary, i.e. to justify a major scheme.

While the development and maintenance of a strategic model can be expensive, in real terms costs have fallen very significantly over the last 30 years. Computer hardware and software is now more powerful and experience shows that the typically achieved levels of validation, against DMRB criteria, are much improved. This, together with improved graphical capabilities, has benefitted the robustness and clarity of model output.

There may be many towns and cities throughout the UK which are covered by models which have fallen into disuse. With a bit of regular maintenance these models could provide local authorities with a powerful and readily available tool. This tool could help the authorities to extract the maximum benefit from the existing network and to appraise minor, as well as major, schemes and developments. However, this would require the value of these models to be maximised.

One way in which the value of these models could be maximised would be to enhance them to be used operationally, i.e. to manage the day-to-day operation of the road network. The driver behind the construction of most models is scheme appraisal (and hence forecasting), which means there is seldom any consideration for how the model could be used operationally. Where operational models are used, they tend to be separate from the forecasting model (e.g. Transport for London's Operational Network Enhancement [ONE] Model). By combining the powerful forecasting abilities of strategic models such as VISUM with the detailed junction modelling capabilities of micro-simulation, a modelling suite capable of both forecast and operational modelling can be developed.

In 2005, SKM Colin Buchanan as part of the JRC consortium, were commissioned to develop a new transport model of Edinburgh and its travel to work area. The proposed model suite included both VISUM strategic and VISSIM microsimulation functionality.

Initially the model was used to assess the Edinburgh Tram project but latterly we have used it in an "operational" role to assess various road closures and diversions. In this paper we will use this model as an example of how the maximum value can be extracted from what might otherwise be an expensive white elephant.

2 – THE EDINBURGH CITY TRANSPORT MODEL

The Edinburgh City Transport Model (ECTM) is a four-stage multi-modal model originally developed in 2005 to forecast patronage on the Edinburgh Tram and its impacts on the highway network. The outputs from the model were used to calculate the expected economic benefit of the scheme and provide input data for the business case.

The model has two tiers: a strategic VISUM model covering the Lothians and Fife; and a series of VISSIM microsimulation models covering the proposed route of the tram including the city centre.

2.1 - VISUM Model

The main strategic forecasting was completed using a VISUM model – this included a revenue model used to inform the business case.

The VISUM model covers the City of Edinburgh Council area in detail; it also covers all major commuting catchments to the city and strategic movements from the rest of Scotland. Road and rail links across the whole of mainland Britain were also included where necessary to allow traffic to travel to/from the study area.

Within Edinburgh, the modelled network includes representations of all significant through-roads. The basis for this network is the OS road centre-line data. This dataset represents a de-facto national standard which guarantees a minimum level of geographical and topological accuracy, sufficient for the requirements of the model.

In addition, adjacent to the tram alignment, each junction has been explicitly modelled down to the number and characteristics of lanes on the approach to each arm of each junction.

Outside Edinburgh, the highway network has been modelled to a sufficiently detailed level in order to allocate strategic traffic to the most appropriate corridor. The basis for this part of the model is the TMfS network. Some degree of simplification has been carried out to avoid unnecessary detail within other town and city centres, particularly Glasgow.

Figures 2-5 below show the extents of the modelled network and the zone system used.

Figure 2: VISUM model - Scotland wide zone system

Figure 3: VISUM model - Smaller zones approaching city centre

Figure 4: VISUM model - location of detailed modelled junctions

Figure 5: Example of VISUM traffic flows within Edinburgh

2.2 - VISSIM Model

The detailed, microsimulation model was built using VISSIM. This model was originally developed independently of the strategic model to look at the operational aspects of the Edinburgh Tram e.g. signal timings and the interaction with general traffic. Later, it was linked to the strategic VISUM model to form a cohesive model suite.

The microsimulation model covers all areas which will experience tram / traffic interaction and any junctions which may be affected by delays directly caused by the trams. This area was too large for a single micro-simulation model to cover practically and was thus split into several smaller, more manageable models. This enabled us to reduce model run times and enable prioritisation of certain model areas (i.e. Haymarket to Ocean Terminal).

The VISSIM model zoning system was based on that of the VISUM model, although disaggregated where appropriate to permit more detailed modelling of traffic movements.

Signalised junctions were represented by fixed time controllers with timings obtained directly from Edinburgh Council's signal control data. Buses were coded directly from timetables and individual bus stops were coded following on-site surveys.

Turning count, journey time and queue length surveys were used to calibrate each VISSIM model area independently. The model covered morning, interpeak and evening peak hours.

Figure 6 shows the extents of the initial 13 model areas. The city centre was split into two model areas: 7 and 8. Improvements in computing power have recently allowed us to combine these areas to provide seamless coverage of the city centre.

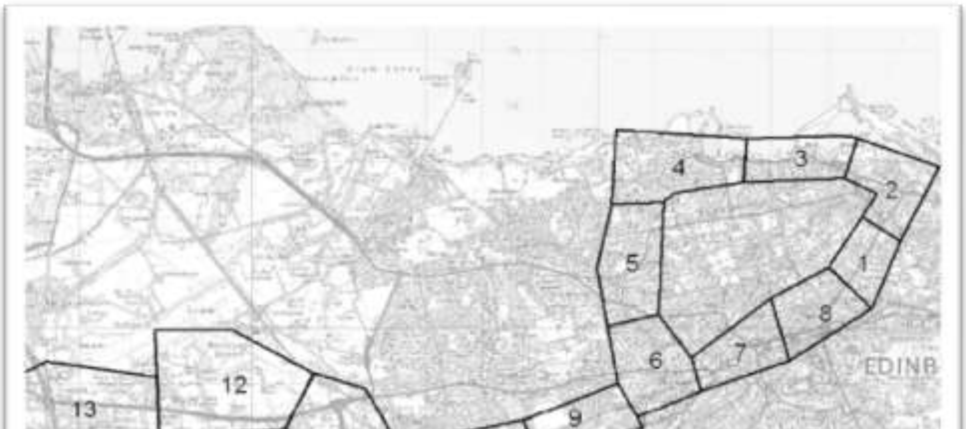

Figure 6: Initial VISSIM model areas – later concentrated on areas 7, 8, 1 & 2

2.3 - Linking the models

Early on in the process we decided that the strategic and micro-simulation models needed to be linked to provide consistency. In other words, some junctions were being changed so dramatically that there would inevitably be changes to the strategic routing of traffic. However, maintaining consistency between strategic level and micro-simulation level models was difficult. Many additional surveys were required for each junction that the tram would pass through in order to ensure accuracy.

The different VISUM/VISSIM zone systems were linked via tables which allowed us to allocate demand from each VISUM zone to one or more VISSIM zones. In this way, the VISSIM models could be calibrated by altering the proportion of demand allocated to individual zones.

A bespoke program was created which would automatically cordon areas from the VISUM model which corresponded to each of the VISSIM models. The program would then extract the cordoned demand matrix and undertake the necessary transformations to convert the matrix to the VISSIM zone system.

In order to ensure that the results of the VISSIM and VISUM models were similar, the models had to be calibrated in parallel. This process was very difficult due to the need to closely match turning flows at so many junctions whilst ensuring that the junction modelling in both programs produced similar levels of delay.

Despite these difficulties, the models all achieved good levels of calibration. Audits undertaken by three independent consultants raised very few issues.

3 - EXPANSION OF THE MODEL'S ROLE

3.1 – Modelling development impacts

The ECTM represents a significant investment for the City of Edinburgh Council which has been keen to maximise the use of the model whenever appropriate. It is no surprise that the model has been used to test the impacts of major developments in Edinburgh. These developments include: Leith Docks, the St James Quarter and the Bioquarter.

Many strategic models are used for such purposes and some local authorities attempt to offset the cost of developing their transport models by charging developers for access to the model. From our experience, and particularly in the current economic climate, it would be unusual for these contributions to cover the initial cost of the model development, let alone the cost of maintaining it. However, high-profile developments can bring substantial economic benefits to the authority, which may outweigh the relatively small financial income from model access charges.

3.2 – Use of the model operationally

The two-tier design of the ECTM, combining the ability to model strategic diversions along with local impacts, was intended to understand the effect of the final tram scheme design some years in the future, but it was soon realised that it could be used to model the present-day effect of construction works and utility diversions.

Using a combination of strategic and micro-simulation modelling, various traffic management scenarios were tested and refined to determine the most effective method of diverting traffic around the closures and other roadwork sites.

Initially, we were asked to model the first major closure of Princes Street, with the view that this would be a one-off exercise, but this method has proven to be so accurate at predicting the traffic response to closures that it has been used for all but one major closure since the works began.

This same method has now also been applied to other major road closures such as the redevelopment of both the National Portrait Gallery and Waverley Steps - both significant developments in the heart of the city. Three case studies showing the process in more detail are presented below.

In our experience it is unusual for a model built primarily as a forecasting tool to subsequently be used to model operational changes to the network; it is difficult to understand why this is! When models are used to forecast traffic demand there are inevitably many assumptions made. Therefore the absolute accuracy of any forecasting model is questionable. Furthermore, it is very rare for anyone to review the model's forecasts after the event to check their accuracy against the actual conditions on-street. Despite this, there is a tendency to rely on these forecasts as if they were infallible predictors of the future. Anyone who relies on the weather forecast will understand how inaccurate any forecast can be!

It seems strange to think that in order to build these forecasting models, we construct what is usually a very accurate model of the present-day situation, and yet it is rare to see these models being used operationally, to look at the short-term impacts of changes in traffic management. Not only is the use of the model in this way likely to be more accurate, but the accuracy can be checked almost instantly against the effect on the ground, allowing it to be updated and improved for future applications.

Whilst the case studies below all refer to temporary traffic management, this example could equally be applied to more permanent changes to the road network, such as changes to junction layouts and optimisation of signal timings.

3.2.1 - Case Study 1 (Princes Street closure)

The first major closure to be appraised in the model was the long-term closure of Princes Street. Although Princes Street is usually only open to buses, cycle and taxis, this still represents a two-way flow of over 1000 vehicles per hour in the peak periods. This led to some understandable concerns: the volume of traffic being diverted to George Street, how well the city centre would operate, and the overall impact on bus journey times and reliability.

The starting point for the traffic management scheme was the contractor's site requirements. Based on this, the contractor's traffic management staff identified potential diversion routes they believed to be practical and which would meet their requirements.

The JRC team were then tasked with modelling their proposals and to refine these to a workable scheme. Both morning and evening peak periods were appraised.

Initial model runs identified a number of critical locations including: Princes St / Lothian Road; Castle St, Frederick St and Hanover St junctions and associated pedestrian crossings on George St. We worked with the contractor, Edinburgh Council, Lothian Buses and AECOM (who would later implement the scheme) to develop a number of alternative options for consultation with stakeholders.

Several initial options were explored using the VISSIM model. At Lothian Road, a simple 3 stage traffic signal arrangement was agreed which improved traffic flow through this busy location.

On George St, modelling quickly showed that the existing roundabouts provided insufficient capacity. While signalising all arms was desirable, to do so would result in a large loss of capacity due to the necessary intergreens between each signal stage. As a result, a preferred scheme was developed which barred one movement on alternating junctions. Figure 7 shows the final scheme.

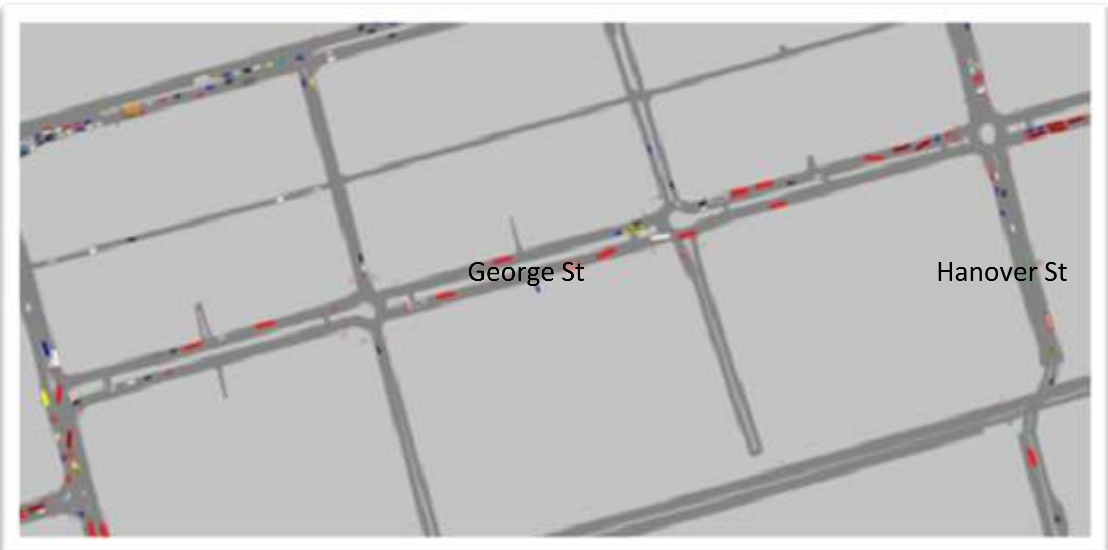

Figure 7: George St final design for Princes St closure

Revisions were also made to George St / St Andrew Square and South St David St / Princes St / Waverley Bridge junctions to improve traffic flow. With a preferred scheme agreed, the VISUM model was coded with the final scheme, and resulting flows were cordoned for the definitive assignment to each microsimulation model.

Traffic flows and signal staging were then passed to AECOM for input to Linsig and Transyt decks. This informed the on-street signal design and implementation. In addition, output from the VISSIM model helped to forecast any increases in journey time for general traffic and buses. This enabled stakeholders to plan for the impacts of the scheme.

Preparing a complex traffic management scheme for implementation in a short timeframe required close co-operation with all stakeholders. An increasingly strong nerve was required as the closure date approached! Of course, there were minor snags on the first day of operation. However, traffic generally flowed well with only minor delays in both morning and evening peaks – much, we suspect, to the annoyance of the local newspaper. Figure 8 shows George St with the traffic management installed.

Figure 8: Traffic management installed on George St

The use of the model in the preparation of the traffic management scheme undoubtedly reduced congestion significantly during this and subsequent closures of Princes Street. This has arguably provided a substantial economic benefit to the city as a result of efficient scheme design, implementation and journey time savings. However, probably more value was attached to the model providing stakeholders with confidence that the scheme would work well from Day 1. This helped to avoid any negative publicity which may have ensued.

3.2.2 - Case Study 2 (Haymarket closure)

More recently, the model suite was used to assess the impact of multiple closures and diversions in the west end of Edinburgh. The purpose of the closure was to finalise the utility diversions under the tram route before building the tram infrastructure itself.

The initial proposal (see Figure 9 below) was to close Shandwick Pl and a large section of Haymarket and West Maitland St simultaneously. This was the largest closure to date, happening as it did in conjunction with a further closure to Princes Street, and was designed to enable the work to progress as quickly as possible. This would potentially save a large amount of time and money when compared to a series of smaller, staggered closures in the same area.

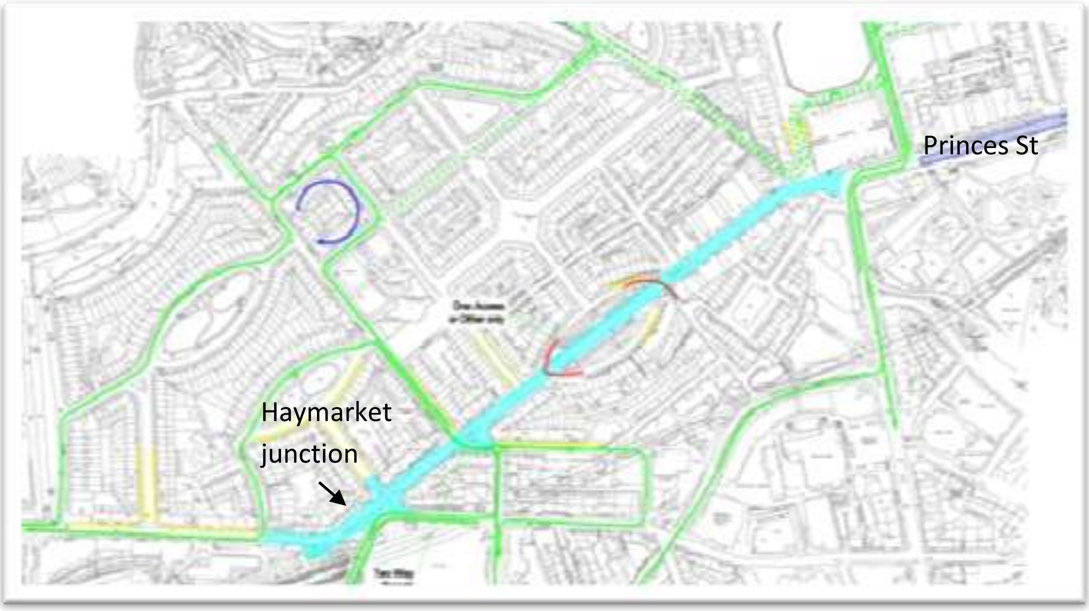

Figure 9: Extent of initially suggested closures (worksite in Blue hatching)

Unlike the previous closures which had been modelled, where our task was to mitigate the impacts, this simultaneous closure would only be deemed viable if the modelling showed it could work without major disruption.

Due to the size of the closure some innovative thinking was required to maintain as many routes through and around the site as possible. The preliminary plans provided to the modelling team already included some radical traffic management including a new one-way system around Palmerston Place, introduction of two-way traffic on the previously one-way Morrison Street, and the reversal of one-way traffic on Torphichen Street.

Most importantly, these plans would provide only one lane for traffic wishing to cross West Maitland St. Shuttle signals would therefore be required to allow northbound and southbound traffic to alternatively pass through the site. Our initial tests showed that this shuttle working would lead to long delays (see Figure 10), so a compromise was reached with the contractors to allow two traffic lanes and avoid the need for shuttle signals.

Figure 10: Initial Haymarket test with obvious long queues

The introduction of a temporary gyratory system on Palmerston Pl also caused a number of issues due to the close proximity of the junctions in this area. Our models were able to assist the design team in optimising the traffic management, including justifying the need for additional temporary traffic signals at a number of other junctions. The model was also able to demonstrate that a bus-only contraflow on Chester St could be implemented (see photo in Figure 11), leading to reduced journey times for buses.

Figure 11: Looking towards temporary Palmerston Pl gyratory with bus-only turn leading to Chester St contraflow

Figure 12 shows how improved traffic management helps to mitigate the long queues shown in the initial test.

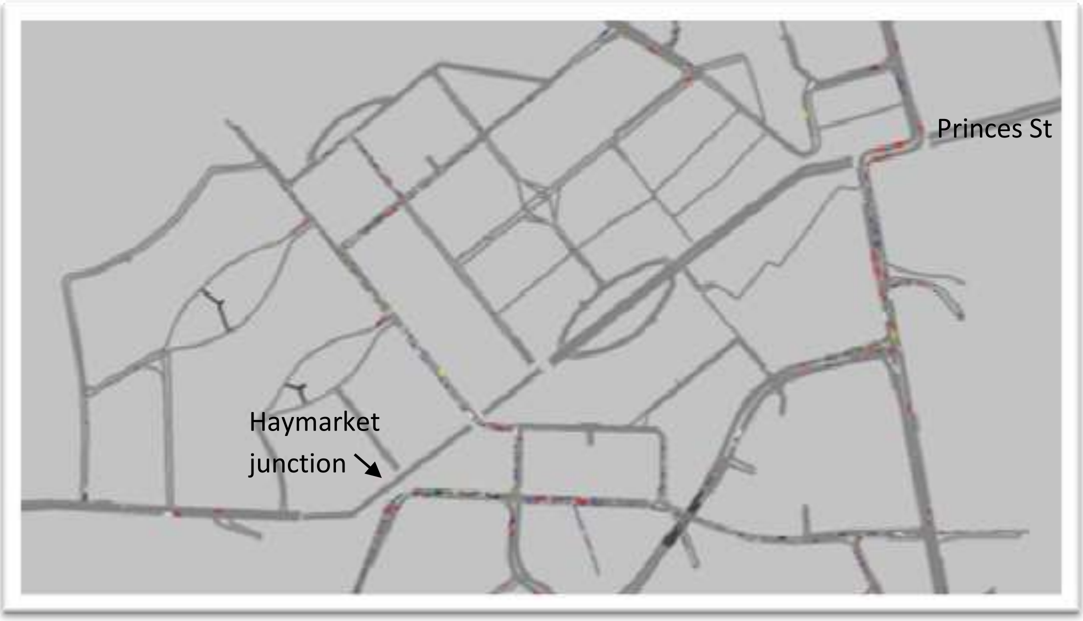

Figure 12: Final Haymarket test with improved traffic management

As with previous closures, the traffic management refinements made possible by the model undoubtedly provided journey time savings to road users. However, had the model not shown that there was a workable solution, this large-scale closure would not have been allowed to proceed at all. The alternative of multiple, smaller closures would arguably have had less day-to-day impact on traffic, but traffic management would have continued for a far longer period of time. The period of time over which local residents and businesses has been affected has therefore been reduced. The contractor has also been able to speed up the work programme, reducing the burden on the public purse.

3.2.3 - Case Study 3 (Queensferry Street - Scottish Gas Networks)

This case study describes the modelling of temporary traffic management for works unrelated to the tram. As part of their ongoing work to replace ageing gas mains, it was necessary for Scottish Gas Networks (SGN) to make various closures along the length of Queensferry Street. The work was to be undertaken in nine separate phases, with each phase requiring a number of diversions and partial closures. Figure 13 below gives some indication of the traffic management involved in just one of these closures.

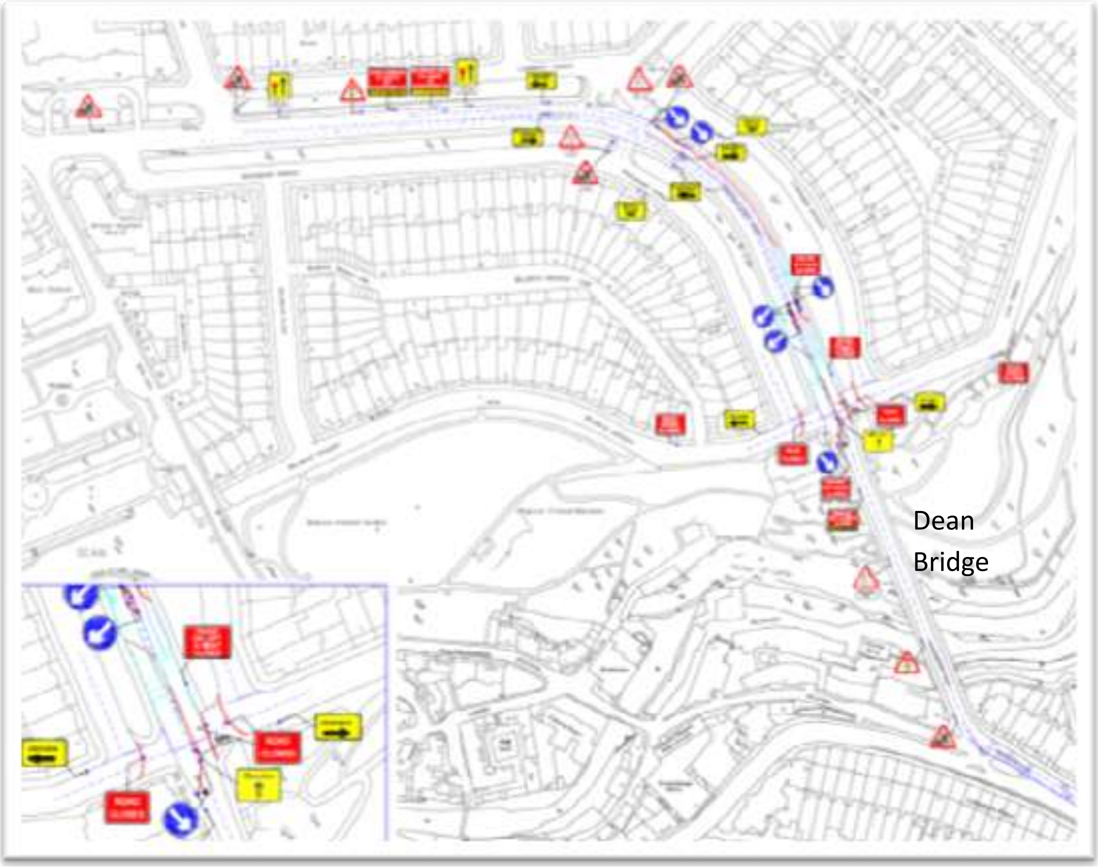

Figure 13: Traffic management for one phase of SGN works

A large element of this work was consultation with various stakeholders including City of Edinburgh Council, bus operators and emergency services. Our role was to provide them with clarity regarding the proposals and assurances that the network would continue to operate satisfactorily. It was also necessary to tie in these closures with the continuing tram works.

Regular stakeholder meetings were held to refine the traffic management proposals. The modelling results were a key element of these meetings as it allowed the stakeholders to visualise the impact of the proposals. One outcome of these meetings was a proposal to close Dean Bridge in one direction with the purpose of reducing the number of vehicles travelling through the area of works.

This was not a trivial closure as 900 vehicles per hour would need to divert via one of the neighbouring bridges at Belford Road or Stockbridge, as shown below in Figure 14. This resulted in the scope of the traffic management widening considerably. The modelling indicated that overall network performance was increased, despite increased delays in the areas immediately adjacent to the alternative bridges.

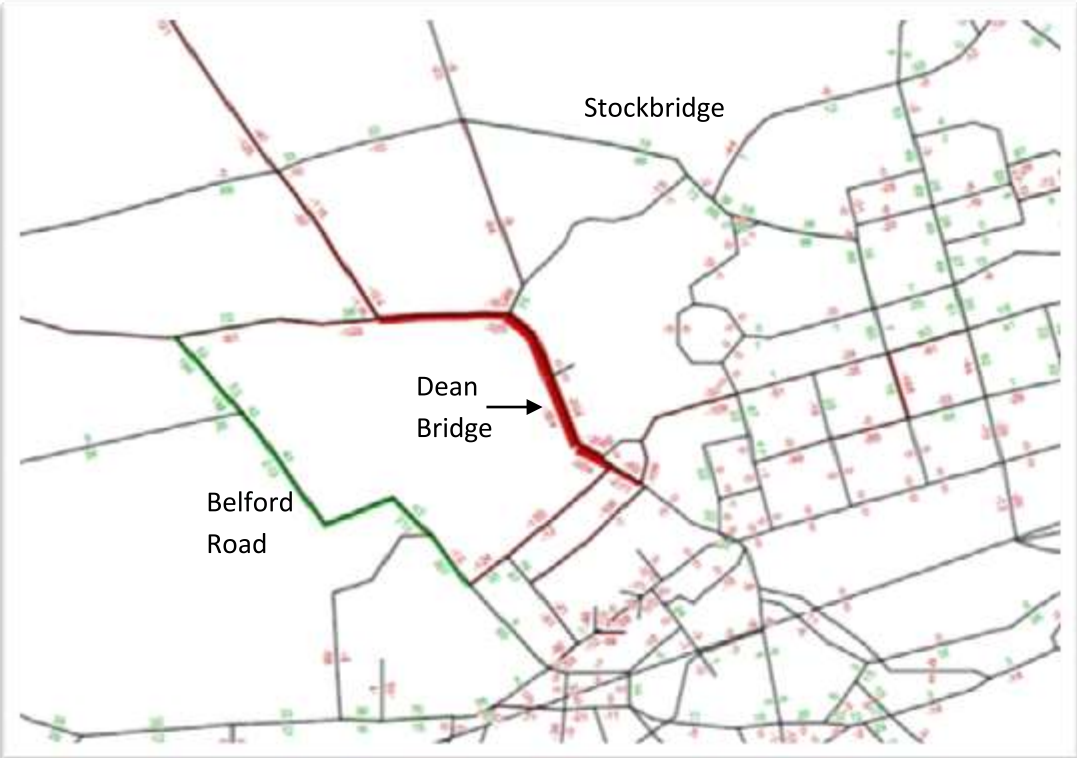

Figure 14: VISUM difference plot showing traffic diverting from Dean Bridge

Again the model was key in allowing the stakeholders to visualise the impacts of the closure; to provide clarity over likely issues; and to give some degree of confidence in a proposal which may otherwise have been dismissed.

Although the closure was proposed for traffic management purposes, it allowed SGN to reduce their work programme by several weeks providing obvious benefits to commuters, local residents and businesses.

3.3 – Consultation

The Queensferry Street case study above highlights the importance of consultation and how models can be used to help stakeholders visualise the impact of proposals. The tram proposals clearly affect a lot of people; consultation is therefore vital at every level, from government to the local residents. This helps to ensure that the needs of local residents, businesses, emergency services and other service providers are met. It also provides reassurance that the proposals will work on “day one” and disruption will be kept to a minimum.

The ECTM has been part of this consultation process over several years, with weekly meetings held with a variety of stakeholders to discuss both the temporary works and the final tram design. Outputs from both VISUM and VISSIM models are used to provide traffic volumes, delays and other detailed network statistics to the client, stakeholders and other consultants. Visualisations from the VISSIM models are also used to help demonstrate impacts to a varied audience. These illustrations include high-quality 3D rendering of the VISSIM model output, this is generally used for presentations to the public. An example of the output which can be achieved from this process is shown in Figure 15 below.

Figure 15: Example of high quality 3D rendering

4 - OTHER APPLICATIONS

This paper has covered only a few of the many tasks to which the ECTM has been applied. The value extracted from the ECTM as a result far exceeds that originally envisaged when the model was commissioned. There are, nevertheless, further applications of the model which have yet to be explored.

The very successful process that has been developed for optimising temporary traffic management could be expanded to investigate more permanent solutions around the city. This could include the appraisal of urban traffic control systems and optimisation of these systems before implementation. Ultimately, the model could perhaps be developed to provide real-time modelling capability. This could allow signals to be optimised in advance of unexpected changes in traffic conditions.

There is also scope to enhance the model to assess the impact of the growing number of cyclists and motorcyclists in Edinburgh and to design safer roads for these users. Finally, there is the potential to model environmental impacts in more detail (Figure 16); allowing junctions to be designed to minimise emissions as well as journey times.

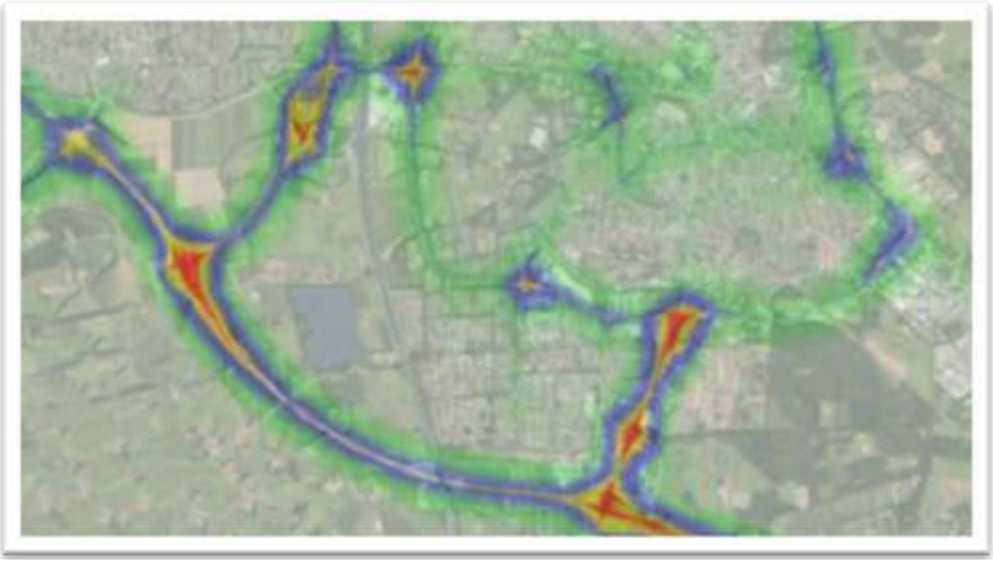
Figure 16: Modelling environmental impact

5 - CONCLUSION

In this paper we have described the Edinburgh City Transport Model and some of the ways that it has been used to date. Following the Edinburgh Tram scheme appraisal we have continued to use the model suite to assess: several other major developments, major road closures and diversions, utility diversion works and non-tram roadworks.

The fact that the ECTM has both strategic and microsimulation tiers has enabled us to use it operationally as well as for forecasting. This flexibility has effectively increased the value which can be extracted from the ECTM modelling suite.

This approach could lend itself to many locations, opening up more potential applications for existing and future models. The use of the model to assist in the development of traffic management schemes has proven itself to be of particular value. This is something which would be of benefit to all local authorities, not just those where major schemes or developments are proposed. Ours is an unusual case in that there is so much construction and so many closures, but these lessons can be applied everywhere.