ROADWORKS: WHAT ARE THE BENEFITS OF MODELLING TEMPORARY TRAFFIC MANAGEMENT ARRANGEMENTS?

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ABSTRACT

Roadworks are an everyday occurrence, for reasons such as routine maintenance and emergency utility repairs.

Chapter 8 of the Traffic Signs Manual gives guidance on how to design temporary traffic management measures for the protection of passing drivers and those undertaking the works, but provides little guidance on whether or how to assess their impacts to the road network.

This paper demonstrates the operational benefits that can be accrued from modelling the temporary traffic management arrangements to assist optimum design, and goes on to discuss what information should be provided to road users in advance of the works commencing.

The use of modelling will be illustrated with results from two case studies: M8 major roadworks to illustrate the benefits for trunk road situations; Gas Mains Renewal in central Edinburgh to illustrate the benefits in urban situations.

The provision of information to road users in advance of the works can have a direct influence on the success or failure of the temporary scheme. The outcomes of the modelling can be used to assist in choosing an appropriate level of information feedback

INTRODUCTION

Our road networks are vital arteries for the movement of people and goods. In urban areas in particular, they are also often the vital arteries for the delivery of other services such as gas, water, electricity, etc. It is therefore inevitable that we need to maintain both the surface and sub-surface services these networks provide. In doing so though, it is necessary to protect those who are undertaking the works and those who are passing the works with temporary traffic management arrangements. These arrangements themselves may also impact on the capacity of the road network which can affect a much wider area.

With the advent of microsimulation models, we now have the necessary tools to robustly investigate both the capacity of the physical temporary traffic management layouts and the impact this will have on the wider road network.

So why isn't this recommended in Chapter 8 of the Traffic Signs Manual then?

The costs of assessing need to be balanced against the benefits that can be accrued.

The costs for the development of an area specific microsimulation model in comparison to the benefits it would provide for assessment of a temporary traffic management scheme are probably at best marginal. However, many road authorities have already or are in the process of developing microsimulation models of their local road network. The commissioning of these models is generally undertaken by the planning / development control sections. The work undertaken by SIAS in central Edinburgh on behalf of Scotia Gas Networks for their Gas Main Replacement programme used a wide-area microsimulation model developed for a completely different purpose.

Even if an existing model does not exist, it may still be worthwhile developing a specific model. Another project undertaken by SIAS was on behalf of Amey through their role as network managers for Transport Scotland for major carriageway refurbishments on the M8 in Glasgow. Some areas of the model did already exist from a variety of other projects but major extensions to the model were also undertaken as part of this commission. This was considered a pragmatic approach given the potentially dramatic impacts of reducing capacity on the M8 though Glasgow.

For brevity, I have used the term ‘roadworks’ rather than ‘temporary traffic management measures’ throughout the remainder of this paper. Temporary traffic management is used in other circumstances (such as event management) and the concepts in this article are applicable to those too.

The first stage to considering the benefits of modelling roadworks is to assess the impact on network capacity of a roadworks scheme. The next stage is to understand how drivers may respond to roadworks.

With this information we can then consider how to use this knowledge to minimise and mitigate any negative impacts that the roadworks may have on the road network.

ASSESSING THE IMPACT ON NETWORK CAPACITY

To assess the impact of a roadworks scheme on the capacity of the road network requires a model. For very simple schemes, a simple spreadsheet may be all that is required. For more complex schemes or those in congested networks, a traffic model will be more useful. The most versatile traffic modelling software for this type of application is microsimulation. The software used in the following case studies was S-Paramics.

A microsimulation model utilises an explicit description of the road network (e.g. number of lanes, permitted turns, traffic signals, bus lanes, etc.) along with detailed interactions between vehicles to produce a realistic representation of how traffic behaves on the road. This can be supplemented with a variety of additional graphics to produce very realistic looking landscapes although it should be borne in mind that these have no bearing on the quality of the underlying traffic model.

Figure 1: Example road network

A base model is developed which will provide a robust representation of typical traffic conditions such as traffic flows, journey times and queues.

The traffic management design is then coded into the model and run.

Reporting

Outputs are taken from the model and reported. Typical results will include the impact of the scheme on traffic flows, journey times and queues. Another major benefit of microsimulation is the ability to observe the model running. This can highlight problem areas which are difficult to explain in tables and figures.

Observation of the model running with the client and the designer of the traffic management scheme can then be used to investigate potential alterations to the scheme and wider mitigation measures. Typical changes include alterations to traffic signal timings, permitted and barred turns, temporary slip road layouts, etc.

The model outputs can also help to identify appropriate diversion routes and aid in where to locate advance warning signs.

Safety vs. Capacity

There's no contest. It is imperative that the safety of those working on the roads is top priority. However, if there are say 5 different roadwork layout options which are equally safe then we can assess which option provides maximum capacity.

Traffic Management on the Trunk Road Network

Undertaking roadworks on the Trunk Road Network and on many key routes in more rural areas will generally require the road to be kept open. A total road closure is unlikely to be acceptable. On dual carriageways and motorways, the locations of crossover points (if any) may also form an integral part of any traffic management.

A recent qualitative survey undertaken on behalf of Transport Scotland by MORI into 'Customer Expectation' of the Trunk Road Network, provided the following main findings in relation to Road Maintenance:

- Poor co-ordination of maintenance works was widely felt to be a problem
- Same piece of road being dug up repeatedly
- The length of time it takes for works to be completed
- Forewarning about maintenance works was widely felt to be inadequate. In particular, signs come "too late" in relation to the repair site.

Traffic Management in the Urban Environment

Working in the urban environment may provide opportunities for more innovative solutions that may not be available on the Trunk Road network.

Firstly, full closures may be possible and may be preferable even when a partial closure could be undertaken instead (see case study 1).

Costs and Benefits of changing the Traffic Management

As the project progresses, it may be necessary / desirable to modify the traffic management. Modelling can also provide an assessment of the relative benefits of altering the traffic management. Changing the traffic management once in place has a cost in terms of the time involved in changing it over and the safety of workers making those changes. A comparison of the benefits of the changes can be assessed against the cost and safety implications of such a change.

CASE STUDY 1 – GAS MAINS REPLACEMENT IN CENTRAL EDINBURGH

This study was undertaken on behalf of Scotia Gas Networks (SGN) to assist in their programme of replacement of old gas mains in Central Edinburgh. The existing gas mains run under some of the busiest streets in Edinburgh and in some cases are up to 500mm in diameter. The nature of the work does not permit it to be undertaken overnight or at weekends. It also requires a number of phases as the laying of the main progresses along its route.

The study investigated the mains replacement over many different roads in central Edinburgh, including Princes St, Leith St, Hanover St, Queen St and Lothian Road.

A preliminary site visit would be made along with representatives from SGN and a traffic management company (e.g. Contraflow Ltd). SGN would explain where they would be working and whether they needed additional road space for plant and materials. Contraflow Ltd would then design the temporary traffic management arrangements (see Figure 2). This would be sent to the appropriate Network Management officer at the City of Edinburgh Council for comment.

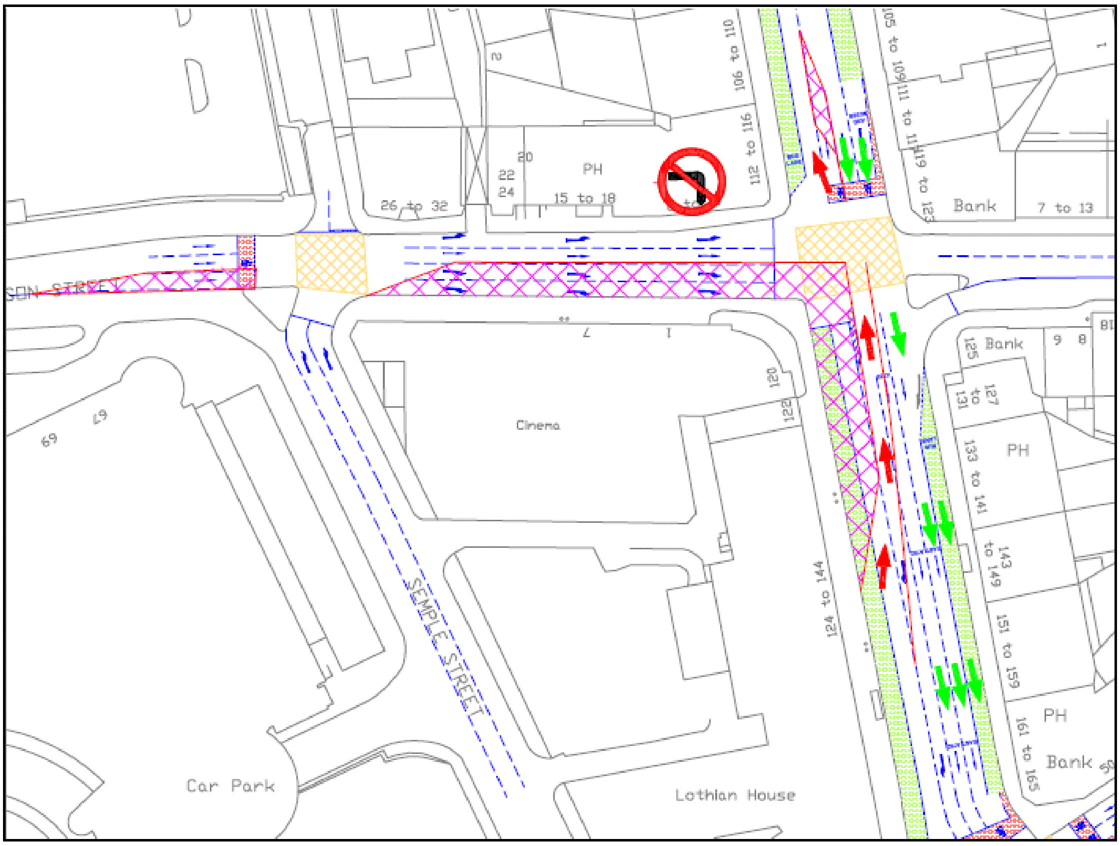

Figure 2: Example Temporary Traffic Management Arrangement (reproduced courtesy of Contraflow Ltd)

Once the preliminary designs were agreed, these would be coded into the Central Edinburgh Paramics Model which had previously been developed on behalf of the City of Edinburgh Council. This model covers the city centre road network from Haymarket in the west to Arthur's Seat in the east and from Canonmills in the north to the Meadows in the south (see Figure 3).

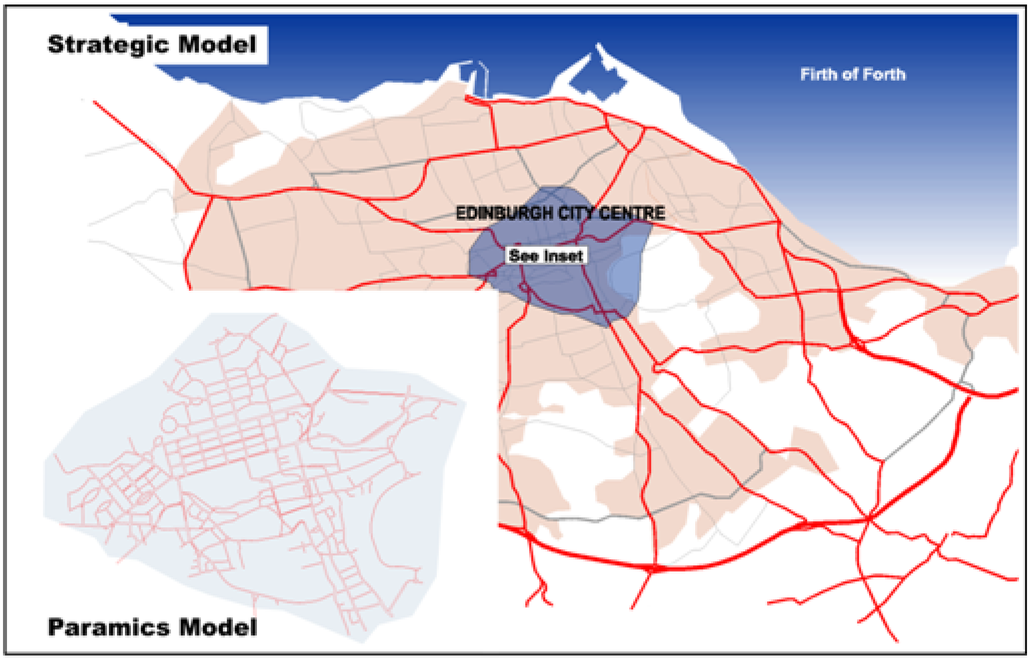

Figure 3: Edinburgh City Centre Paramics Model Network

An iterative process was then undertaken with SGN and Contraflow to refine the traffic management to minimise any congestion problems.

The results from the modelling along with the traffic management designs would be presented to a meeting of key stakeholders which typically involved representation from the Police, Public Transport operators and a variety of council officers with a remit for traffic signals, network management, environment etc.

The process would then be repeated as necessary taking cognisance of input from the stakeholders (e.g. preferred Public Transport diversion routes).

One benefit from modelling all the full programme of the replacement works was illustrated by the Princes St project. Naturally for this area, a key output from the models was the impact that the different stages of work would have on the bus travel times. The modelling indicated that what was considered to be the most disruptive stage which involved a full closure in one direction with attendant diversions via other streets actually provided shorter travel times than an earlier stage where only one lane was closed off.

Consequently, the full closure plan was adopted for all the work on this section. This also had the added benefit that it enabled a larger working area for the Gas Mains team which resulted in less down time as they could keep more materials and plant on site. One of the reasons for the benefits of the full closure was that it simplified the adjacent traffic signal staging for three closely spaced T-junctions.

Reporting

At the stakeholder meetings, a key challenge for this project was how to summarise the wide variety of technical outputs from the model for the various phases of work on each route. To go into detail on each phase would have resulted in very long meetings.

On this study, the reporting evolved into the production of a subjective ranking of 1 (little impact) to 10 (major impact). This was based largely on engineering judgement with special emphasis on the impact on Public Transport. This is an area which could benefit from further development of a more rigorous and transparent methodology for how to objectively combine a wide range of impacts.

Another useful output from this model was the identification of where the traffic that would be affected by the roadworks had originated. This provided SGN and Contraflow Ltd with the necessary information to locate advance warning signs of the roadworks in a targeted rather than 'blanket' manner. The benefits of this approach were reduced costs from fewer signs, fewer drivers seeing signs irrelevant to their trip and for drivers who know their way around Edinburgh, sufficient prior warning to seek alternative routes.

Implementation

Once the programme of work was agreed by all the stakeholders, the outcomes from the modelling were used for a variety of purposes.

In addition to the necessary Temporary Traffic Regulation Orders (TTROs) required for the scheme, any additional restrictions recommended from the modelling were also created.

SGN would contact the local press to explain the works and the likely delays. Contraflow Ltd created signs for the recommended diversion routes and erected appropriate warning signs at key locations in the city centre.

3 February 2007

The phase of the Lothian Road replacement project that was predicted to have the most detrimental impact on the city centre road network was that at the junction with the West Approach Road.

Progress on the earlier sections had proceeded well and this junction was reached ahead of schedule. The decision was made to proceed with the work on the weekend commencing 3 February 2007 but with little prior notice provided to both public and private road users.

Public Transport operators reported delays of more than 90 minutes for some services across the capital and thousands of passengers delayed for up to an hour.

CASE STUDY 2 – M8 MAJOR ROADWORKS

This study was undertaken on behalf of Amey to assist in the design of the traffic management necessary for the reconstruction roadworks on the eastbound M8 (undertaken Summer 2006) and westbound M8 (planned for Summer 2007) carriageways in Glasgow from Junction 24 (Helen Street) to the Kingston Bridge.

Whilst this model was developed specifically for this project, much of the road network was inherited from previous studies in the area. The model coverage is shown in Figure 4 (for clarity only part of the model is shown. The full model extends along the M8 corridor east to Junction 12).

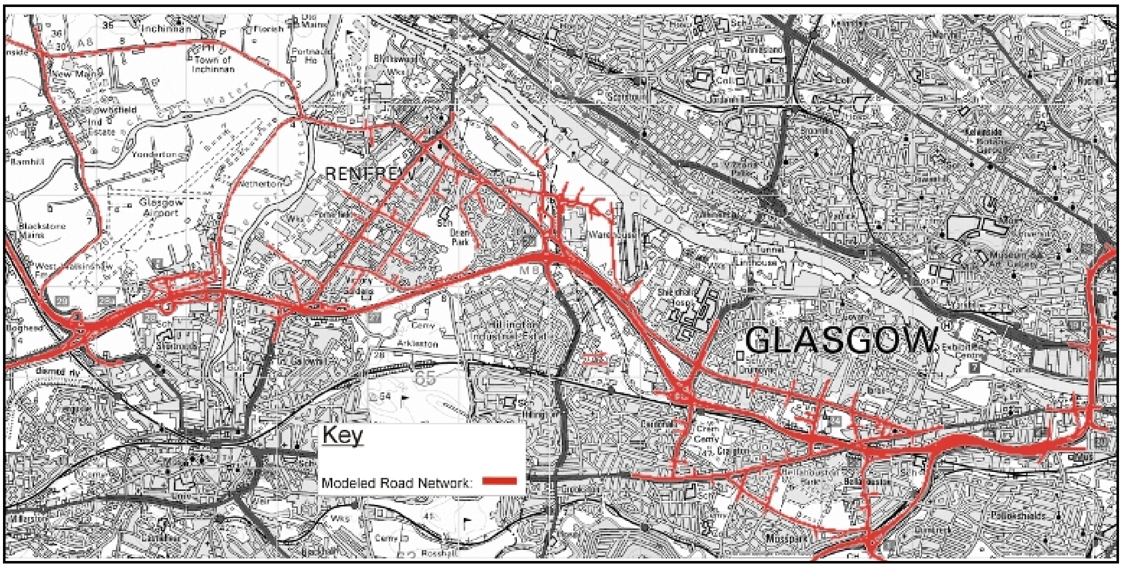

Figure 4: M8 Roadworks Testing Model Network

The carriageway of the M8 main carriageway in this section of network was deemed to be in need of replacement. Given the daily flow of over 150,000 vehicles on this section of motorway, this presented a significant logistical problem. The extent and nature of the work does not permit it to be undertaken overnight or at weekends. Various phases of work were required to enable the resurfacing to progress whilst maintaining sufficient mainline motorway capacity and access at junctions.

The study initially investigated the carriageway replacement on the eastbound section between Helen Street (J24) and the Kingston Bridge. Continuing work on the study will investigate the roadworks options on the corresponding westbound carriageway, which is scheduled for replacement in the summer of 2007.

Close collaboration between Transport Scotland and Amey was required to identify the various potential options for phasing the roadworks. The options had to be devised to strike the appropriate balance between safety, manageability, cost, duration and other factors whilst maintaining sufficient capacity to accommodate traffic and minimise delay on both the motorway and surface street network. Central reservation cross-over points, junction closures and the potential for constructing temporary links between the M8 inner and outer braids at Plantation Interchange (J22) were also key considerations in defining the options.

Ultimately, 20 to 30 options / phases were devised and tested using the S-Paramics model. An example of these is shown in Figure 5.

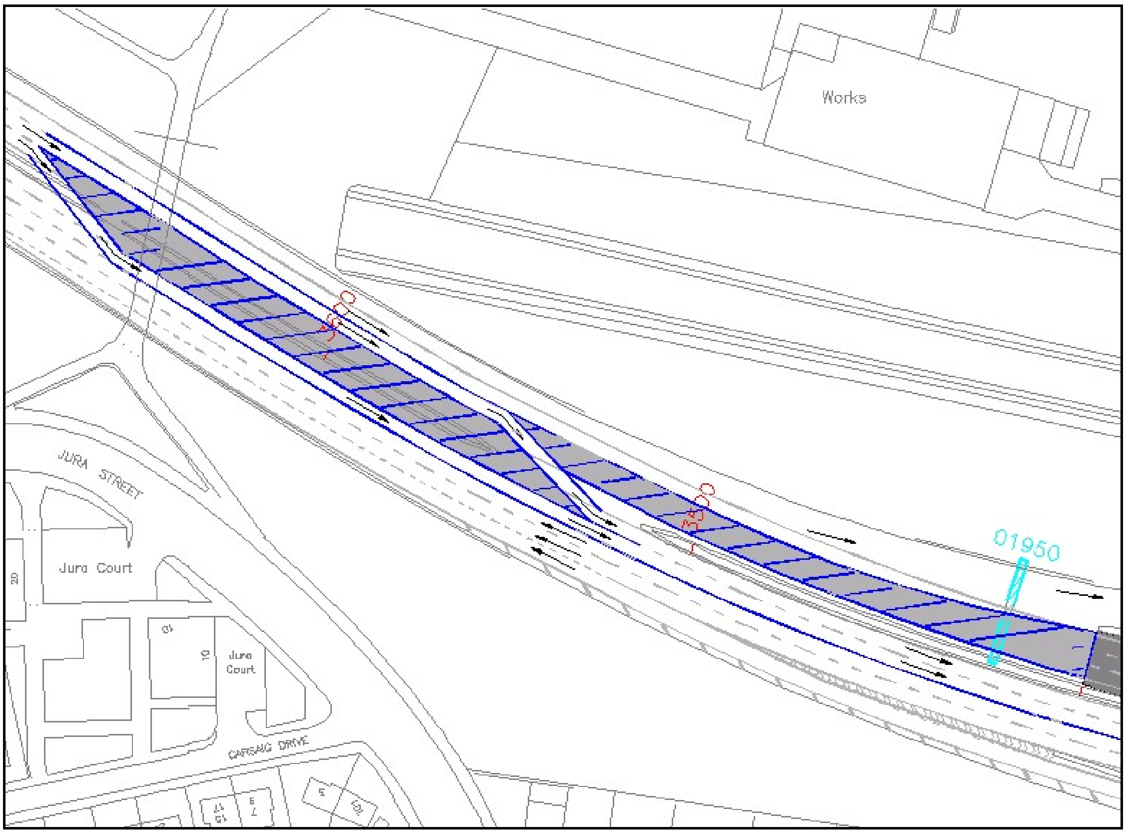

Figure 5: Example of Temporary Traffic Management Option: M8 Eastbound

Following the development of the options, a representative subset of these was modeled using CSTM3A to identify if any wider area re-routeing effects may occur following implementation of the roadworks. This modeling indicated that wider area effects were likely to be relatively small and hence, the Base Year, weekday travel demand matrices were adopted to enable a “worst case” assessment of operational conditions during the roadworks.

An iterative process was then undertaken whereby SIAS would model the various options and report back the resulting operational conditions to Amey. Further refinements were devised by Amey to minimise any congestion problems and the operation of the amended options was remodeled using S-Paramics.

The results from the modelling along with the traffic management designs would be presented to a Traffic Management Forum involving key stakeholders including representatives from the Police, Transport Scotland and Local Authority officers with a remit for design, safety, traffic signals, network management, environment etc.

The scale of expenditure on this roadworks scheme made it subject to approval from Transport Scotland Investment Decision Makers (IDM). Consequently, the modelling outputs were presented, both graphically and analytically, at an IDM meeting, following which approval to proceed was granted.

One of the key considerations of the modeling exercise was vehicles response to congestion and alterations to route choice within the network. In particular the Traffic Management options included the closure of several junction on-ramps, and changes in the operation of the trunk road network.

The existing model was developed, and tested, to ensure that vehicles response to delay was realistic. Microsimulation was of great benefit to this process as the build up of congestion could be realistically modeled and vehicles’ dynamic response to network conditions robustly represented.

Ensuring that the response to congestion within the base model was realistic enabled the option testing to be completed with greater confidence in the outcomes of the modelling. The base existing model was a robust platform from which to perform scenario testing.

Reporting

At the stakeholder meetings, a key challenge for this project was how to summarise the wide variety of technical outputs from the model for the various phases of work on each route. To go into detail on each phase would have resulted in very long meetings.

The model operation was simplified to show the development and dissipation of congestion through the day within the study area. The roadworks scenario was overlaid with the base model to highlight any areas where the proposed scheme produced more congestion than the base situation.

An example is shown in Figure 6 where the layout of the roadworks result in a change to average vehicle speeds when compared to the base situation. In this example, areas in red are where speeds have decreased whilst those in green are where speeds have increased.

This output was particularly straightforward for the non-technical stakeholders to understand and clearly showed the impacts of the traffic roadworks scenarios.

Figure 6: Example of congestion display showing changes in vehicle speeds

Implementation

Once the programme of work was agreed by all the stakeholders, the roadworks were publicised both locally and nationally in advance of their implementation. The works were implemented over the summer period beginning in early July 2006 and ending 12 days earlier than programmed on Tuesday 19th September 2006. Hopefully a similarly successful programme will be implemented for the westbound section in due course.

DRIVER RESPONSE TO ROADWORKS

There is a wealth of evidence relating to how people respond in general to *permanent* changes in the transport network and the subsequent increases or decreases in congestion that ensues. These responses can be summarised as:

- Change Route
- Change Time of Journey
- Change Mode

- Change Frequency of Journey
- Change Destination
- Change Origin

In relation to the assessment of roadworks though, not all of these responses will occur. It is unlikely that anyone would move home in response to roadworks. In relation to destination choice; travel to work is also very unlikely to change. However, destinations such as those for leisure and shopping may be affected depending on the impact of the roadworks during the periods of the day when these trips are made. Likewise, the frequency of leisure and shopping journeys may also be affected. Changes to mode of travel will be dependant on the impact of the roadworks on alternative modes. If buses are equally affected by the roadworks, car drivers are unlikely to transfer. Major works on the trunk road network may however lead to some transfer to rail. In more urban areas, switching mode to cycle or walking may be possible.

The most significant responses though will be to change the time of the journey (i.e. set off early to try and either avoid the delays or just take account of the longer travel time). Dependant on the location of the roadworks, diversion to alternative routes is also very likely.

For the assessment of a temporary scheme, the 'higher' level individual choices provided in a transport model are either difficult to predict due to lack of evidence or unnecessary.

One option is to undertake a 'worst case' scenario with most of the 'higher' level responses disabled. Hence, with a wide-area model, the only response to the roadworks will be the option to choose an alternative route where there is a road closure, banned turn or delays are high enough to make an alternative route a better option.

This scenario could be realistic if the roadworks proceeded with no prior warning to drivers! Hence, it provides an indication of how extensive the advertising of the roadworks should be and how these warnings should be conveyed to the motorist.

Depending on the extent and location of the roadworks it may also provide an indication of other measures that may be required. For example, if say the Kingston Bridge in Glasgow had to be closed for 2 months, the remaining road network would not be able to absorb all this traffic. Substantial numbers of drivers would have to transfer onto Public Transport to access their workplace, but it is unlikely the Public Transport network would be accommodate these increases in demand either. Outputs from the modelling could be provided to the Public Transport operators to aid them in their decisions about where to provide additional capacity or services to meet this need.

ADVERTISING THE ROAD WORKS

With a prior assessment of the impact of the roadworks and an understanding of the psychology of driver responses to these; appropriate warnings of delays can be deployed. However, it is important to avoid if possible two longer term detrimental effects. These are "sign blindness" and "cry wolf".

Sign Blindness: Drivers who are familiar with the road network that is being affected will often see and read a new sign only once. They may then be 'blind' to any changes on that sign.

Cry Wolf: This is a complex problem. If you warn of for example 'severe delays' and enough drivers respond in advance such that the delays do not occur, you have lost an element of trust in the signage. An analogy to this would be the introduction of the 'Central Edinburgh Traffic Management Scheme. The Edinburgh Evening News was an ardent opponent of the scheme and predicted chaos and gridlock at its introduction and ironically was probably a significant influence in its success. A perhaps more relevant example is the use of advisory speeds on roads in response to phantom traffic jams. If drivers respond to the advisory speed then they stop feeding the back of the phantom jam so that the jam dies. However, those drivers who have responded to the advisory speed signs only see an open and clear road ahead of them and then think the network managers are incompetent rather than smart and are next time more likely to ignore the signs.

If we consider these two problems together, it is advisable if possible to start with the most disruptive stage of the roadworks if technically possible. With prior warning, drivers will adapt their travel patterns. After a few days demand will have adapted to the conditions as best it can. If the less disruptive elements follow then conditions will continue to improve rather than deteriorate.

Should we adopt more or less variation in the signing on the roads for warnings of delays? If drivers are made aware of delay when the roadworks are in place, it is probably too late. Prior warning is useful, but a road sign is not the place on which to put lots of information relating to the relative impacts. It is highly recommended to stay with signing as advocated in TSRGD (Traffic Signs, Regulations and General Directions) and Chapter 8 of the Traffic Signs Manual. To provide more information in today's multimedia world, consideration of other methods of information dissemination is probably a better solution to a sign on the road. For example, there are Driver Information Websites such as Traffic Scotland. There are also local and national government websites. Depending on the scale of the roadworks, local and national newspapers and radio may also be appropriate.

CONCLUSION

Our roads are becoming ever more congested. This in turn leads to the need for those responsible for keeping these networks running to have available the tools to assess the impacts of temporary traffic management measures.

The development of microsimulation modelling and the gradually increasing availability of existing microsimulation models provide useful tools for understanding these impacts.

Two case studies have been presented in this paper to illustrate how the use of microsimulation modelling has been used to successfully assess and refine traffic management measures in an urban and a trunk road environment.

Outputs from the models were used to aid understanding of the impacts for both technical and non-technical stakeholders and to assist in the development of both physical and non-physical mitigation measures such as:

- Signed diversion routes
- Placement of advanced warning signs
- Advertising (e.g. Newspapers, internet, radio)

Where there is predicted to be more than minor congestion, the manner in which forecast delays are reported to the public should be done in cognisance of the psychological responses that drivers will have to congestion and signing.

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