Microsimulation: An important tool in the designers armory

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Traffic modelling is often the trusted mechanism to help aid delivery of transport and highway schemes but sometimes crucial factors, such as vehicle behaviour are not adequately considered in some strategic approaches. This paper considers the role of microsimulation modelling and how it can play an important part in the design process to help overcome such issues.

In the UK, the North Wakefield Gateway scheme has used microsimulation to good effect to inform the scheme design, quantify the likely benefits and assist with public consultation.

Transport and highway schemes are often implemented with high expectations based on the predictions of traffic modelling. However, schemes sometimes fail to live up to those expectations due to vehicle behaviour that is often not considered in traditional modelling processes and not taken into account in the design. By example of the North Wakefield Gateway scheme in Wakefield city in England, this paper shows how traffic microsimulation can play an important role in the design process to help avoid such issues whilst in
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The North Wakefield Gateway comprises the parallel routes of the A61 Leeds Road and A650 Wentworth Street, both of which are key radial routes into the city, providing important corridors for public transport as well as general traffic. To the south of the area lies the Emerald Ring – Wakefield's partially completed Inner Ring Road. The area also includes the Merchant Gate mixed use development, the St John’s conservation area and important buildings including the Grade I listed Town Hall and County Hall, Police headquarters, as well as a number of other listed buildings and buildings of local interest.

The area currently suffers from peak time congestion, which is exacerbated by traffic associated with Wakefield Girls High School and the Queen Elizabeth Grammar School. This congestion affects public transport and general traffic on the key radial routes into the city, and also impacts on the operation of the Emerald Ring with more strategic consequences. Committed developments associated with regeneration within the North Wakefield Gateway and the city centre are likely to further worsen the congestion in the future.

Addressing traffic congestion within the North Wakefield Gateway is therefore a priority for Wakefield Council. The key challenge is to achieve this objective whilst also providing better connectivity for buses, cyclists and pedestrians. This need to be done in a balanced manner that is sympathetic to the conservation area and listed buildings, and can be delivered within the constraints of those buildings.

In 2008, Wakefield Council was allocated a share of funding from the Regional Funding Allocation Uplift Grant, which is managed by the West Yorkshire Integrated Transport Authority, to implement a transport improvement scheme for the North Wakefield Gateway.

INITIAL PROPOSALS

The initial proposals developed by Wakefield Council for the North Wakefield Gateway were for a large gyratory system comprising the A61 Leeds Road, Rishworth Street and the A650 Wentworth Street. The conversion of the A61 Leeds Road and A650 Wentworth Street to one-way working would free up road space to allow full inbound and outbound bus lanes to be provided, as shown on Figure 1. However, following extensive public consultation which indicated strong local opposition to the scheme, it was considered that this proposal would unacceptably reduce the accessibility of the area, with long, circuitous routes being required for access and egress to many properties in the area.

In response to this, the Council set up a working group comprising local residents, community representatives and local councillors to suggest alternatives. The group favoured a smaller gyratory system of A61 Northgate, Rishworth Street, A650 Bond Street and Wentworth Terrace, as shown on Figure 2. Since the majority of the A61 Northgate and A650 Wentworth Street were to remain two-way, this option resulted in a slightly reduced length of inbound bus lane but largely addressed the concerns about local accessibility raised during the public consultation.

A MICRO SIMULATION APPROACH

Following the successful implementation of Aimsun microsimulation modelling to consider public transport priority measures along the A642 and A638 corridors in West Wakefield, the Council commissioned a study using the Aimsun software to model the revised small gyratory proposal for the North Wakefield Gateway. The aims of this work were to assess its likely operational performance and to assist with communication of the impacts of the proposals to key stakeholders, especially considering the controversial public response to the original proposals.

Microsimulation models use a realistic and geometrically accurate representation of the highway network that includes the detailed specification of lanes, junctions, permitted turning movements, traffic signals, priorities and gradients. Traffic signals are also reflected accurately, exhibiting fixed time, vehicle actuated and other control methods as required.

Vehicles are considered individually with properties such as vehicle size, acceleration rates, maximum speed, parallel adding significant value to a project.

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Aimsun Model Extents and Validation. Green circles represent links with a GEH statistic of less than 5

Figure 3: North Wakefield Gateway Aimsun Model Extents and Validation. Green circles represent links with a GEH statistic of less than 5
deceleration and braking rates, speed limit accept ance and car following distances to name a few. These parameters are sampled from probability distributions defined by the user as part of the calibration process and therefore each vehicle has a unique set of parameters that govern how the vehicle will move through the network. Using these parameters, and other parameters defined for the network, the vehicles are moved through the network following a number of behavioural models including car following, lane changing, gap acceptance, overtaking, merging and diverging models.

Each bus route is also individually specified within the modelled network along with detailed timetabling for each service including start times and the specification of timing points. The bus stops that each service calls at are inputted along with the dwell time at the stop. Dwell times and service departure times are also subject to variation based on probability distributions, in a similar way to other model parameters. This allows the variation in bus stop times that occurs in practice to be represented.

By representing the highway network and the vehicles upon it in this detailed way, microsimulation offers a number of benefits over strategic modelling:

- A wide range of complex geometries can be represented;
- The effects of interactions between adjacent junctions and beyond are considered, including blocking back of queues;
- Traffic demands are accurately modelled with the temporal profile matching that observed on street rather than considering an hourly average (ie peaks within the peak are modelled, which is important in locations around schools, for example);
- The impact of different traffic signal control methods are represented;
- Bus lanes and bus stops, including delay caused to buses and other vehicles as a result of bus stops are modelled.

A more detailed explanation of the benefits of microsimulation is presented in "A microsimulation approach to modelling bus priority", TEC, October 2010.

We will go on to show how the full and proper consideration of these details during the modelling process is critical in understanding how a proposed highway scheme is likely to operate and the consequences of not taking these issues into consideration.

MODEL DEVELOPMENT

The Aimsun model covered the two parallel arterial routes of the A61 and A650 from Westgate and Marsh Way in the south to Newton Bar in the north, as shown on Figure 3. The choice of study area for the Aimsun model was influenced by the need to include sufficient network coverage to incorporate the full extent of the proposals and local realignment effects (with strategic realignment effects to be covered by the existing SATURN model, as discussed below) whilst minimising modelling costs for the Council. The network was coded in the level of detail that can be afforded by microsimulation, as discussed above. The Wakefield District SATURN model was used to provide the demand for the Aimsun model both in the base year and in the future years, with and without the proposals in place. In this way, any strategic realignment that would occur as a result of the proposals would be reflected in the Aimsun model. However, within the Aimsun model, dynamic traffic assignment was used to enable the detailed impacts of the proposals on route choice to be considered, principally between the A61 Leeds Road and A650 Wentworth Street routes.

MODEL VALIDATION – A REAL LIFE TEST

The Aimsun base model considered the network as it stood in 2008 and was calibrated and validated in the usual way, meeting the standard validation criteria set out in the Design Manual for Roads and Bridges, as shown in Figure 3.

A do minimum model was also produced that included the completion of the Mulberry Way section of the Emerald Ring – an inner ring road for Wakefield that passes through the model study area. Following the completion of the model, Mulberry Way was opened to traffic and provided a useful test of the validity of the model and its ability to predict future traffic conditions. Encouragingly, the model accurately predicted the nearside queuing on the new one way link shortly after opening. Traffic counts undertaken during the post implementation period have also been compared to the predicted traffic flows in the model and these show a good level of agreement, as demonstrated in Figures 4 and 5.

AN UNEXPECTED FINDING

The small gyratory option was coded into the Aimsun models and the models were run. It was expected that the...
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Aimsun model would confirm the effectiveness of the proposed solution and quantify the benefits that would result. However, when run, the model showed significant congestion and a worsening over the do minimum situation, as shown on Figure 6. In such situations, the normal reaction is to question the validity of the modelling. A number of sensitivity tests were run, which colluded to confirm the original findings. Further interrogation of the model showed that the congestion was occurring due to the effects of queuing traffic at one of the new junctions on the gyratory blocking back to the upstream junction, reducing the capacity of the upstream junction. This in turn reduced the capacity of the next junction on the gyratory and so on until and the system eventually became gridlocked. Whilst optimisation of traffic signal offsets improved the situation, the only strategy to effectively manage the queues on the gyratory was to hold back traffic on the approaches to the gyratory. This, however, resulted in further impacts on other junctions and unacceptable delays for drivers and public transport users.

A review of the design using the Aimsun model showed that the issues could be addressed by providing additional capacity at the number of locations in the scheme. However, there was insufficient land available to provide the additional capacity enhancements required and the resulting gyratory was largely out of character with the surrounding environment. For example, there would have needed to be a four lane highway directly adjacent the Grade 1 listed County Hall, which would have been unacceptable.

AN ALTERNATIVE APPROACH

The Aimsun model was then used to inform the development by the Council of a further alternative and more innovative highways scheme.

This was achieved through an interactive workshop session between Council officers and the modelling team using the Aimsun model as a design tool to test the impact that various alterations to the proposals would have on the model outcomes.

In particular, it was noted that the gyratory approach was increasing traffic flows significantly in some constrained locations, such as along Wentworth Terrace, and blocking back at a critical junction, close to County Hall, by virtue of all traffic being routed around the proposed small gyratory system.

In order to unblock the system, and to provide for the large volume of traffic movements making the north-south movements, the gyratory was amended to allow two way traffic flow on the eastern and western sides of the system, which otherwise would have to be routed around a large portion of the gyratory. Two-way traffic flow could be accommodated within the efficient two-stage signal cycles of the previous proposal, however, due to the lower levels of circulating flow, enabled these locations to operate more efficiently. It was anticipated that these changes would relieve much of the queuing, providing significant capacity benefits.

Following the workshop session, the alternative layout was worked up in more detail by the Council, including the provision of a new bus-only lane in front of County
The new proposal was tested within the Aimsun model, as shown on Figure 7. It was reassuring that the Aimsun model confirmed the assumption that the revised scheme would provide significant benefits over the do minimum situation and would be able to satisfactorily accommodate the forecast increase in traffic associated with the large amount of committed development associated with the ongoing regeneration of Wakefield city centre.

In addition to addressing the principal capacity concerns, the revised scheme also had a number of other important benefits. The closure of Bond Street in front of County Hall provided the opportunity to create a new area of public open space that would significantly improve the setting of this Grade 1 listed building and would provide an enhanced environment around the cenotaph monument. The savings achieved from the reduced scale (and more effective) highway scheme, contribute to the environmental improvements possible in this area.

Further public consultation was carried out on the revised proposal; almost a year after the original consultation had taken place. This demonstrated that the new scheme was now largely supported by the public and local members. Further minor changes suggested through the public consultation were incorporated and the proposals were then retested in the Aimsun model for the final time. Officers were concerned that the changes would give rise to increased congestion due to the increase in complexity and conflicts that they created. However, the changes suggested at the public consultation did not adversely affect the predicted operation of the scheme. Analysis of the model showed that the changes lead to journey time benefits for the drivers and occupants of those vehicles. The less convoluted routes also reduced traffic flows on a number of other links, freeing up capacity on those links and associated junctions.

STAKEHOLDER COMMUNICATION

Videos of the operation of the network for the morning and evening peak periods were produced to enable officers to demonstrate the outputs from the model without needing access to the Aimsun software. These videos were available when discussing the proposals with a wide range of stakeholders including the police and local schools, colleges and churches. In addition, the model was demonstrated to West Yorkshire Metro and bus operators by running the model ‘live’ in an interactive session. This allowed the proposal to be viewed allowing questions to be answered immediately or taken away for further analysis. For example, the bus operators were interested in the changes in journey times for each individual service. This data was subsequently outputted from the model, confirming that their flagship services would experience significant benefits, as shown in Figure 8.

SUMMARY

In summary, Aimsun microsimulation modelling has been used to great effect on the North Wakefield Gateway proposals as a design tool, an assessment tool and a public consultation tool. It has enabled the delivery of a more effective scheme with the added benefits of the creation of a significant area of high quality public open space and an improved setting for a Grade 1 listed building and the cenotaph monument. The investment in the modelling work is more than justified by the added value that it has brought, with additional value in the legacy that the model can be adapted and enlarged for analysis of further city centre highway improvements and scenario testing. The North Wakefield Gateway scheme is currently under construction with a completion date of June 2012.

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