Action plans

Changes to traffic management strategies can be complex and costly. **Lauren Ansell** speaks to experts in the field of microsimulation to find out how data and complex algorithms can be used to make road traffic planning more detailed, accurate and cost-effective

Image: Toronto 2015 Pan Am & Parapan Am Games

Road traffic simulation has been around for more than 50 years, but it is only in the past two decades that such models have been considered intelligent enough to be a viable alternative to more traditional modeling approaches. This is not only attributed to advances in technology, but also to a realization by the industry that more detail and accuracy was needed in the evaluation of traffic scenarios.

"In the past, crude assumptions were made in developing several models that dealt with more general aspects of traffic, rather than looking at a specific issue," explains Saad Yousif, program leader of transport engineering and planning at Salford University, UK. Today's advanced microsimulation models, however, are able to determine the movements of individual vehicles

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> **Saad Yousif, Salford University, UK**

(Left) **The 2015 Pan Am and Parapan Am Games will have a major impact on the Toronto landscape this summer**

traveling around road networks by using car-following, lane-changing and gap-acceptance rules. The models are now so realistic that traffic planners are relying on them to assist with overcoming challenges. For example, microsimulation will play an essential role in region-wide transportation plans surrounding the summer 2015 Pan Am and Parapan Am Games.

"The most advanced models offer more flexibility in making proposed changes to road layouts, or monitoring variations in traffic conditions and traffic behavior, than empirical models," says Yousif. One simply alters the programming code in the software.

"These models are considered to be powerful tools and are being used to help designers, planners and road authorities make informed decisions about the impact and effectiveness of changes to road layouts, signals and junctions," Yousif adds. "Traffic performance measures can include journey speeds, delays and queue predictions for certain areas."

Most models currently used by the industry also provide a visual depiction of traffic movements. "This means they can easily and clearly illustrate places where bottlenecks occur in response to certain changes," says Yousif. "Therefore suggestions for alleviating such bottlenecks and hotspot areas can be made by altering certain parameters within the model. This may involve making changes to the geometric design, altering the information given to drivers, introducing different controls such as changes to speed limits, providing enforced measures or prohibiting certain movements. The proposed changes can be tested in the model without the need to physically implement them on-site. The impacts of these changes can then be evaluated and assessed."

Yousif's research confirms that, if implemented correctly, microsimulation models can be used to successfully evaluate the impact of introducing new roadway infrastructure, such as ramp metering on motorway slip roads. "In this instance, the model uses values for certain parameters to trigger the traffic signals at the ramp," he explains. "Such parameters include traffic flow rates on both the ramp and the mainline motorway lanes, speed reductions on the mainline motorway lanes, changes in occupancy in certain lanes and queue lengths on the ramp. This information is then used to optimize the operation, by triggering the traffic signal controls and determining the length of the cycle time."

Microsimulation models have also proved to be an effective tool in considering the impacts of changes to road markings and signage, particularly surrounding temporary workzones and in the case of major sports or music events in urban areas.

Ahead of the game

The 2015 Pan Am and Parapan Am Games are expected to draw more than 7,000 athletes and 1.4 million spectators to Toronto and Canada's Greater Golden Horseshoe region. With congestion already a problem in the area, it has been essential for organizers to find a way to better manage travel throughout the region during the Games, and ensure optimized transportation for athletes and officials.

To this end, the Pan Am/Parapan Am Transportation Team (PATT) has been working on a C$60m (US$51m) transportation plan, which includes a Games Route Network designed to provide safe and reliable travel for the Games Family. The plan includes the introduction of traffic management measures such as a temporary priority lane network (PLN), parking restrictions, prohibited turns, public transit adjustments and road closures.

To evaluate the implications of creating a PLN for Games Family transport, the PATT decided to use the Aimsun hybrid simulation package from Transport Simulation Systems (TSS) to model the region's highways, with priority lanes added for high occupancy vehicles (HOV). This is not the first time the region's authorities have made use of such simulation techniques. The Ministry of Transportation, Ontario (MTO), has used traffic simulation modeling for highway planning and design, construction, operational reviews and traffic management strategies for several years (see *Traffic Technology International* April/May 2012). However, it is the first time MTO has used this method to anticipate a special event of this size. With competitions taking place in 30 venues over a 2,046 square mile (5,300km^2) area, the combined Games are set to be one of the largest events of the kind ever to take place in Canada.

(Above) **Regional authorities are using microsimulation models to make informed decisions about traffic management during the Games**

"Our experience has shown that mesosimulation and microsimulation, in conjunction with macro-level demand modeling, is the most effective methodology for evaluating the traffic operational implications of changes to the highway system," explains Goran Nikolic, head of traffic planning at MTO. "This is particularly true with respect to a congested highway system where time dynamics plays an important role. Microsimulation also enables us to evaluate the implications of overlapping and interacting highway features that could only be considered in isolation using analytical techniques."

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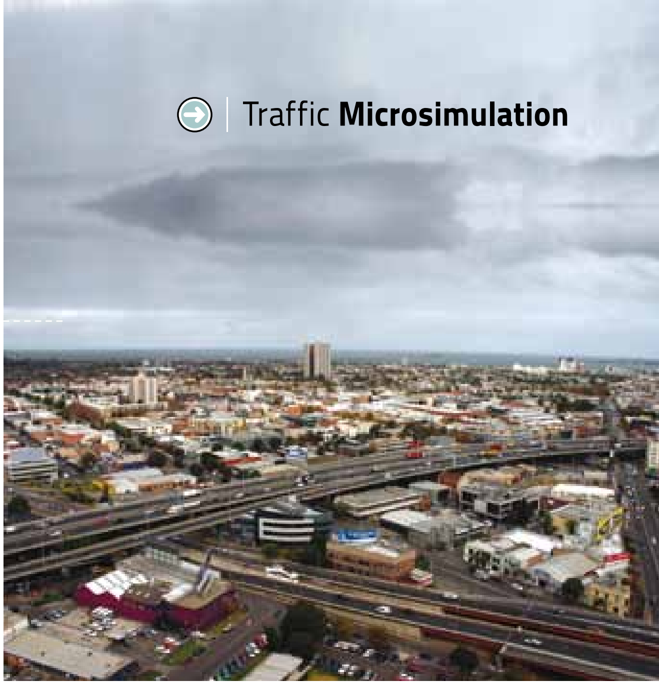
> **Saad Yousif, Salford University, UK**

The Aimsun simulation model, which was created using detailed information from the Land Information Ontario GIS system, comprises three levels of detail: macroscopic, mesoscopic and microscopic. As such, it delivers the fast computational benefits of mesoscopic modeling while enabling the organizers to zoom in on more congested or troublesome areas without having to change over to a different software package.

"The software has enabled us to evaluate the potential consequences of implementing traffic management solutions during the Games," says Nikolic. "We have been able to consider both the level of service provided to athletes and Games officials, as well as the impact on the traveling public. We have evaluated various eligibility options for the PLN and have considered how the public might adapt and respond to proposed traffic management measures."

The results from the model suggest that implementation of the PLN will have a positive impact on Games Family transport, while simultaneously benefiting the greater highway system. "It's useful to have this kind of technical support when making key policy and planning decisions," says Nikolic. "The simulation results are playing a key role in decisions currently being made."



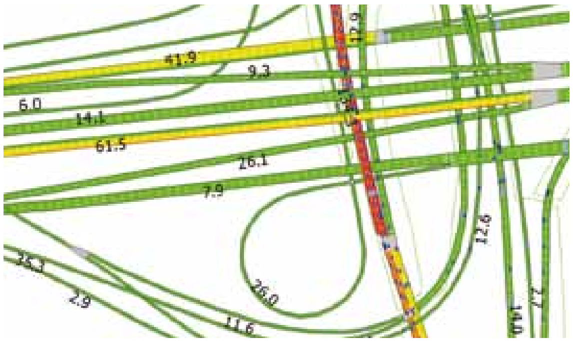
Quality matters

Verification, calibration and validation are essential parts of the modeling process

While microsimulation can be extremely useful, Salford University's Yousif warns that inaccurate data will result in a false representation of reality. "Rubbish in will lead to rubbish out," he says. Furthermore the unpredictable nature of road traffic makes management changes extremely complex. "Driver behavior and choice of location within the road space is much more difficult to predict and model than, for example, a train on a railway track," says Yousif.

While it is impossible to clearly identify and quantify all the factors that influence driver and vehicle behavior, most current microsimulation models contain user-adjustable parameters that control factors such as driver aggressiveness, car-following sensitivity and threshold speeds. This enables operators to replicate local conditions as accurately as possible.

"To ensure that a microsimulation model is developed properly, a series of verification, calibration and validation processes must be conducted," says Yousif. "Knowledge of the local conditions will reduce the chances of making improper assumptions, or accepting biased output results from the model."



(Left) **The Aimsun traffic model for the Pan Am games area comprises a larger mesoscopic-level area with some pockets of microscopic modeling**

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> **Goran Nikolic, Ministry of Transportation, Ontario**

While Nikolic recognizes that there is always a possibility that the real-world consequences of new traffic management strategies could differ from those predicted by the model, he believes that accuracy can be optimized by using common sense and engineering judgment gained from experience with the local highway system and traffic conditions. He understands that the success of this type of simulation analysis is dependant on the quality of the inputs available, including forecast travel demand and existing traffic volume and speed data.

"We would recommend this approach, provided that the required input data is available at a suitable quality level and provided that sufficient lead time is provided to avoid the need to rush the modeling process," he says, adding that detailed evaluation can be a resource- and time-intensive process. "We have a reasonable level of confidence in the results but there is no practical way to assess this level of confidence," he admits. "However, our level of confidence using any other methodology would be much lower. The amount and quality of the information obtained from the simulation model would simply not be possible using other methods."

Modeling mobility

The high level of detail provided by microsimulation models has also made them useful to researchers in Australia evaluating the viability and effectiveness of on-demand urban mobility. The iMoD (Intelligent Mobility on Demand) project was launched in 2011 by a team of academics from the University of Melbourne and Monash University to investigate how demand-responsive transportation (DRT) could increase mobility and access in growing cities, in a sustainable way. The development of highly detailed computer simulation models has been integral to their research.

"Traditional strategic approaches tend to be too high level to model DRT in reasonable detail," says Nicole Ronald, the research fellow in collaborative transportation for the Department of Infrastructure Engineering at Melbourne University and one of the iMoD initiative's key researchers. "Traffic microsimulation, however, where the precise movement of vehicles is modeled down to acceleration and deceleration, is ideal for small areas and for scenarios where demand-responsive vehicles could frequently stop, have their own lanes, or receive priority at traffic signals.

"Microsimulation enables us to explore the effects of individual choices and behavior, particularly the

Micro management

A microsimulation model proves that road authorities don't need to make huge investments in infrastructure to combat congestion at intersections

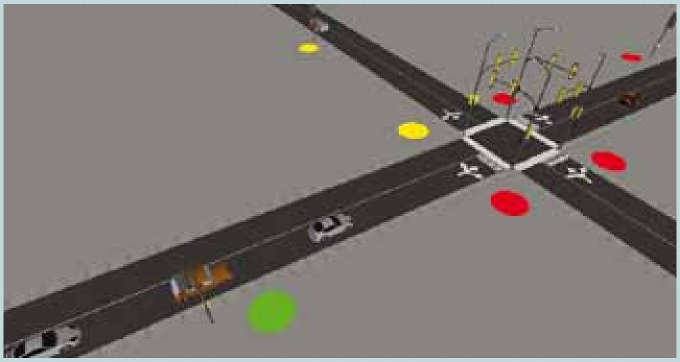
With the aim of finding a simple, cost-effective solution for overcrowded intersections, a research team from the University of Minho, in Portugal used microsimulation to evaluate how the implementation of pre-signals on intersection approaches could improve traffic flow and reduce waiting times.

"Our theory was that pre-signals would improve the efficiency of intersections," explains Luís Dias, assistant professor at the university. "So we used microsimulation to create models that make a realistic comparison between intersections with and without pre-signals." The input data was based on field observations as well as research and experience.

The researchers used a tool called Simio, which uses an object-oriented paradigm. "The tool enabled us to include variables such as vehicle acceleration and driver reaction times," says Dias. "That meant we could make the models as realistic as possible." The model also provided the flexibility to change the type of intersection (with or without pre-signals), the distance between a pre-signal and the main lights at each approach, the traffic light green time and the traffic intensity.

The model showed that the cars using the intersection with pre-signals waited one minute less than the cars using the standard intersection. Furthermore queues were shortened by 60m and traffic flow increased by 15%.

"We found that in heavy traffic a distance of 40m between the pre-signal and the traffic light was ideal and in light traffic the



distance doesn't influence the performance of the intersection," says António Vieira, a researcher at the university who worked with Dias on this project.

The model has been verified and the team is confident that the results could be replicated in the real world. "We are now working on a model that compares the performance of an intersection with pre-signals with the performance of a roundabout," says Vieira. "We're also looking at emissions and fuel consumption."

Videos of the model can be found at traffictechnologytoday.com/micro

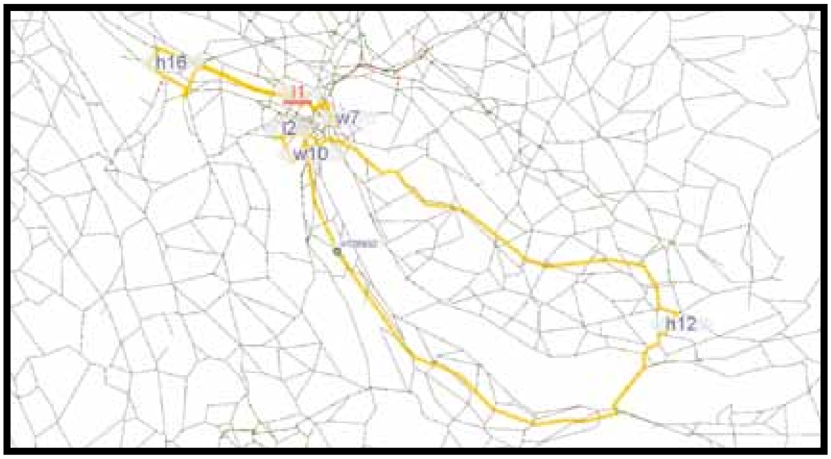
interactions between vehicles and people," Ronald continues. "For example, it can take into account individual driving behaviors and explore the effects on other vehicles, or look at how changing working hours will impact rush-hour traffic." This is particularly useful for DRT, as the routes of vehicles are determined by passenger requests.

An integrated approach

The iMoD researchers have looked at three types of model so far. "We started by creating our own DRT-only software from scratch, which enabled us to explore some of the effects of changing the number of vehicles, vehicle sizes, and demand patterns," Ronald explains. "However, this did not incorporate other traffic, which could affect the performance of the system. As a result, we have developed a prototype of DRT simulation on top of traffic microsimulation and found it was more useful for exploring detailed operations."

Ronald's team has also been using an agent-based microsimulation software package called MATSim, developed by TU Berlin and ETH Zurich, which has been previously used to model vehicular traffic and public transport for large areas, such as Zurich and Singapore. "Up to now we have been simulating DRT alone," says Ronald. "Our next step is to integrate the DRT model with other modes. This will enable us to evaluate multimodal systems and quantify costs and benefits for our project partners."

One current iMoD project is using microsimulation to explore how different types of DRT schemes could



(Above) **An agent-based microsimulation model of an area in Zurich, using MATSim software**

work in two neighboring towns in regional Victoria. Here, fixed route buses were replaced with a demand-responsive service in late 2013. At set times during the day, a vehicle starts from the center of one town and picks up and drops off passengers as requested. If there are no requests, the vehicle does not travel.

"We created a model of this as our base, alongside an altered scheme without the time constraints – so the vehicle runs the whole day," describes Ronald. "We can now develop demand estimations and costings for these schemes. Using data from the real-world service enables us to ground the model, and will lead to use for other towns in Victoria."