Local Transport Today October 2009

Capacity management: a future with few limits?

The 2004 Traffic Management Act has focused a great deal of highway authority attention on how to maximise the capacity of their road networks as efficiently as possible and the 2009 JCT Traffic Signal Symposium features several key papers concerned with this thorny topic. Rik Thomas reports

The Traffic Management Act 2004 has bestowed certain duties on local authorities relating to the movement of traffic within their respective highway networks and, in order to demonstrate that the highway authority and the appointed traffic manager are managing the network efficiently, an understanding of the network's operation is obviously required. "In order to achieve this operational understanding, metrics will need to be developed such that baseline operational characteristics can be collected and then acceptable levels of operation developed," Martin Wylie, traffic signals engineer at Southampton City Council, explains in a paper presented at the JCT Symposium. "Once the network operators understand the boundaries of acceptable operation, triggers can be put into place to monitor these operation thresholds and subsequently investigate potential methods of maintaining these acceptable levels of network operation, thus further demonstrating the management of the network. This paper sets out one authority's approach to defining these traffic management metrics relating to the movement of traffic."

Wylie's team at Southampton was asked to develop a network management tool that could be used to assess the likely impact of additional traffic demand on the network and to assist in the process of defining the baseline metrics that would be used to measure the effectiveness of the city in managing the movement of traffic. Southampton has the benefit of a vast amount of live traffic data being fed into its traffic control centre thanks to the widespread deployment of Urban Traffic Control (UTC) and SCOOT, he points out. The city has 261 automatic traffic flow count locations linked back to the ROMANSE (Road Management System for Europe) control system – these count locations cover all of the main routes. Using the count sites located on the five main ingress and egress routes for the city a comprehensive record of daily flows is logged and stored in a specially designed database. Also being logged are the green and inter-green times for the signalised intersections on the five main routes. Average route speeds derived from the SCOOT system are also logged.

A number of classified counts have also been taken, along with turning counts at strategic intersections. This data has been used to assist with profiling the automatically collected data and produce turning trends and the classified

Southampton council's Martin Wylie

topology of the traffic demand.

"The analysis and assessment of traffic flow and the efficiencies thereof have many possible paths, for instance looking at traffic density, headway, speed occupancy curves, etc," Wylie explains. The method used in Southampton was to first assess the capacity of each of the main route sections and then produce route-based capacity baselines, therefore identifying sections where demand outstrips capacity along with sections that have spare capacity. "The rationale for this approach was that, where no long-term restriction to the flow of traffic on the network exists, traffic will flow at a given percentage of capacity based upon the available road space and traffic demand; it is only where the traffic flow demand outstrips the capacity or is restricted in some way that the free flow capacity varies," he says. "Having studied the routes in Southampton, which are not unusual in the urban environment, the instances where restriction to flow exists are at give-way or signalised intersections. Southampton is quite fortunate to have most of the intersections on the main routes signalised, thereby making the assessment of capacity easier."

Traffic flow data is collected from the UTC system and hourly mean flows are derived for each section of each route. At signalised intersections the respective green times are also logged from the UTC system and again hourly mean green times are derived for each main route approach to the intersection. Using CAD plans and aerial photographs the nominal free flow capacities of the main route sections were estimated. "With this approach capacity weighting factors were derived, enabling nominal capacity for both free flow sections and restricted sections to be determined," Wylie says. "Once these baseline capacities had been calculated the hourly mean traffic flows could then be assessed against the nominal available capacities, thereby determining the capacity of each section."

Working at the front

A team of consultants from Mott MacDonald, lead by Andrew Walsh, was then tasked with defining a way to present the network capacity assessment output such that it was intuitive and easy to use and the resultant output clearly understandable. Having looked at a number of options, including spreadsheets to map overlays, an open brief was given to Dr Beshr Sultan and his colleagues to produce the 'front end' for the capacity assessment. The resultant 'front end' displays the hourly mean traffic demand and the percentage of available capacity by hour; this data is complemented by a graph that makes for easy assessment of the route section. Route section capacities can be displayed for a 12-hour period for each day type for each month; multiple capacity assessment tools can be opened in parallel.

Deriving the effect on section capacity by the addition of increased traffic demand, Sultan and his colleagues then moved forward with the next objective, which was to demonstrate the effect that additional traffic demand would have on an individual route section. The impact on the baseline capacity was added to the section capacity tool such that a second graph would be added to the additional baseline graph and a visual indication of the effect of the additional traffic demand could be seen, along with the raw data to allow for further analysis. The additional flow can be added for the 12-hour period or for an individual hour. This links the individual intersections together such that the impact of additional traffic through a diversion can be automatically assessed on a number of sections in a route, so that the overall impact can be understood, rather than treating each section individually.

"Now we have derived the relative capacities of our main routes we can firstly demonstrate our management of the network through the ability to assess the impact of additional traffic demand, for example diverted traffic or imposed network

Talking to the neighbours on the TIH

TIH stands for the Traffic Information Highway – it is a framework and a community supporting the traffic and travel information sector in exchanging data to enhance the information available to both operators and travellers. The basis of the TIH model is the exchange of information between an information publisher, wanting to make information available, and an information receiver, seeking to obtain information; in most cases organisations will have both information publishers and information receivers but the distinction helps to separate the two sides in any exchange.

According to Dr Peter Bull, traffic information and control manager at Sheffield City Council, the aim of the TIH community is to help members build universal system-to-system links to exchange travel information, saving money, time, duplication and effort over the 'build-your-own' model that had prevailed in the past. By sharing experiences, the TIH community has distilled its knowledge into a framework of guidelines known as the TIH principles, a set of simple rules to define a common approach based on proven techniques and best practice.

"Computers don't like surprises," Bull explains. "To effectively exchange information, the format of the data needs to be agreed in advance. If the data doesn't match exactly what the receiving system is expecting to see, the exchange will fail. Following the TIH principles makes sure that we all make our data available in a common format and use common standards for locations, event types, etc."

"The TIH principles do not compromise your data ownership, nor do they imply a data warehouse," Bull adds. "TIH is not a system in itself, just the agreed framework for joining many systems together over the Internet and it sets out the rules for these key areas of data exchange." The TIH community currently has 517 members (as of June 2009) in both the public and private sector, such as A-One, GCap Media, Google and the BBC. 41 local authorities have signed up, including Cambridgeshire, Lancashire, Nottingham, Sheffield and Reading.

As an agreed framework for joining systems together via the Internet, TIH uses a 'common practice' approach to exchange travel information. It only adopts practices that are both relevant to all members and conform to international standards, Bull says. These common practices are collectively known as the TIH principles – they provide advice on compliance, usage agreement, expert guidance and set out rules for data exchange. The principles are that:

Any charging mechanism should be clearly described.
The authentication level should match the value of the data.
Data should be published using XML with compression.
Data and publication models should be described adequately.
For location referencing an international standard should be used, ideally TPEG-Loc or at least WGS84.

"There is no mystique or complexity to the principles – just some common-sense approaches that we can all work with," Bull explains, noting also that this advice and guidance can be accessed through the recently revitalised TIH wiki – www.tih.org.uk

Anyone with an interest in a particular area of investigation can join the relevant TIH working group, he points out. Each group is led by a recognised expert in that area and their main task is to monitor current developments and emerging standards and to assess their impact on the TIH or the principles. The actual work of the groups takes the form of debate, either in person, or using the wiki discussion facilities sitting behind each working group's web page. The working groups are:

ITS Data Content Definition: how we describe the data we exchange.
ITS Interfaces: how we exchange data technically.
ITS Location Referencing: how we describe where something is on a road or public transport network.
Data Quality: how we describe service levels and the quality of the data.
TIH Communications: how we communicate with ITS professionals.
TIH Mobile: delivering information to mobile devices.

Bull points out that the Traffic Management Act of 2004 has created a statutory duty for those in local highways authorities to facilitate the flow of traffic on their own network and also, significantly, on those of their neighbours. "For this we need to exchange data with different parties, both other authorities and private sector organisations," he says. "Following the TIH principles allows us to build system-to-system links for exchanging traffic and travel data that save time and money. It also enables the DLOA (detailed local operating agree) process to be more effective and supports potential eDLOA development. Business and software toolkits are available to speed up development and the TIH community helps you to embrace existing common practices by bringing practitioners together to share their hard won experience."

What's coming along the highway?

The Secretary of State for Transport has guaranteed fundamental administrative support for the TIH community until at least 2011, which means, Bull says, that information publishers and receivers can therefore be assured that the longevity of the TIH principles is guaranteed. "Recently, TIH has been revitalised by a project initiated by the Highways Agency to help road authorities to co-ordinate traffic management measures through sharing traffic data with neighbouring authorities," he goes on to say. "This will be through the adoption of TIH principles and implementation of DATEXII compliant data exchanges." Specific activities within this project will include:

Promoting the use of TIH principles internally within the HA
Promoting the use of TIH principles externally to local authorities
Promoting the use of TIH principles by NTCC to ensure it is exploiting the technology
TIH Community promotion and DATEXII
Co-ordination of working group activities

From September onwards:
Revision of web pages
Revision of TIH principles documents
Closer ties with ITS UK

Based on the new HA policy, which has been founded on TIH principles, UTMC and DATEX II, the HA entered a period of consultation that ended in July, Bull points out, observing also that, after this, all current draft policy will be reviewed and formally issued. "The HA has developed this policy in line with industry best practice and in consultation with the supply chain and important to note is the move from 'guidance' to 'mandatory' policy," he concludes. Further information is available at:

http://www.tih.org.uk

TIH also helps with international issues, particularly in relation to participation in standards setting. On 16 December 2008, the European Commission took a major step towards the deployment and use of Intelligent Transport Systems (ITS) in road transport. They recognised that ITS can significantly contribute to a cleaner, safer and more efficient transport system. However, use of ITS in road transport in Europe is still uneven. A patchwork of national, regional and local solutions is slowing down overall deployment and fails to provide seamless service. An action plan has been adopted that suggests a number of targeted measures and a Directive is being processed that will lay down the framework for their implementation. The goal is to create the momentum necessary to speed up market penetration of mature ITS applications and services in Europe. It is being proposed to accelerate and coordinate the deployment and use of ITS applications and services for road transport and their connections with other modes of transport, to ensure seamless access and continuity of services throughout the EU.

restrictions such as a lane closure, but we can also present how efficient our main route network is at dealing with the average traffic demand by producing hourly main route capacities; this can be further enhanced by the addition of average route journey times or any data supplied, such as average speeds derived from floating car data," Wylie says. "By evaluating the sections that are over capacity for the potential of capacity improvements we can further demonstrate our management and understanding of our network."

Engineering solutions

According to consultant engineers Sanderson Associates, as traffic volumes increase and peak time congestion grows, more sustainable methods of improving traffic flow are required. "Due to an increase in awareness of environmental issues, widening the carriageway and providing additional traffic lanes is not always seen as a viable option,' company managing director Alison France explains. "Often, capacity problems only occur during the peak periods with freely operating junctions during the off peak periods. Costly widening is wasteful both in monetary terms and environmental terms to improve conditions for only two to three hours per day. Often by simply revisiting the timings for either a single signalised junction or a network of signalised junctions (many of which will have been in use for years without any adjustments) capacity benefits can be gained."

France adds that, in some instances phase lags can be introduced (by extending phases into the intergreen period so that terminating phases reach the end of green at different times), which can gain additional green time for the critical traffic links. "Where this is not the case, considering alternative staging plans can also be very useful," she points out. "Sometimes this may require slight amendments to traffic islands, kerblines and pedestrian crossing layouts but will deliver not only an increase in capacity and reductions in delay and queuing but also safety benefits and improved facilities for pedestrians. For example, on a project that we are currently involved with, identifying minor adjustments to a large five-arm junction for a for a large superstore development in the north of England saw a substantial increase in capacity at the whole junction through the removal of a pedestrian all red stage. Due to the existing layout of the pedestrian crossings, an all red stage was required to service all the pedestrian demands but, with the identification of an extension of a central island, this allowed a crossing point to be relocated and simple amendments to the staging meant that all pedestrian phases could be accommodated as 'walk with traffic'."

On another recent superstore development that Sanderson worked on, simply running the side roads separately gave capacity increases and improvements in safety terms as no movements were opposed by oncoming traffic. "It is easy to see that only minor amendments can make a big difference," France concludes. "When these are coupled with technological advances such as MOVA (an improvement on normal vehicle actuated control where traffic volumes on all arms of a junction are considered before a stage change occurs, thus reducing overall queuing and delay), a big difference in safety, capacity and reduced queuing and delay can be seen."

There will eventually come a point when road networks cannot accommodate any further traffic, she does concede, but up until then some small changes which cost little and help the environment can give great results.

Interface issues

In a second paper presented at the JCT Symposium, Southampton's Martin Wylie explained recent work he has been involved with to link traffic control systems with the latest traffic modelling software. "In the world of transport modelling the microsimulation software tools are leading the way in evolving the options and interfaces that constantly improve the realism of our transport models," he says, before setting out the development process and functionality of the new Aimsun-to-Siemens UTC (Urban Traffic Control) interface incorporating TRL's SCOOT (Split Cycle Offset Optimisation Technique) algorithm.

The Aimsun suite of products developed by TSS (Transport Simulation Systems) incorporates three modelling tools; a macroscopic model, a mesoscopic model and finally a microscopic model, Wylie explains, noting that, although Aimsun has been linked to SCOOT for many years, TSS has now incorporated the interface to the Siemens UTC SCOOT off-line software within the Aimsun product.

The model interface to the Siemens UTC SCOOT off-line system was developed using CORBA, with data being passed between Aimsun and UTC and vice-versa. From the model UTC receives the detector data and Aimsun receives the stage control data from UTC, Wylie explains. When pairing SCOOT with Aimsun, the micro-simulator is the 'owner' of the clock that controls the process. When detection data is available it is sent to SCOOT. SCOOT is, thus, a reactive system waiting for data that it processes and then sends back to Aimsun. Both systems work in an asynchronous way – SCOOT signals the availability of new control data to Aimsun and then Aimsun connects again with SCOOT to fetch and implement the new control plan information.

"Updating an existing microsimulation model to allow SCOOT control is relatively easy," Wylie claims. "First we have to add a SCOOT controller for each signalised node in the network and then associate the SCOOT controller to a respective signalised node. The signalised node is updated to allow external control and then the SCOOT detectors are added to the model and once again associated to the signalised node and the SCOOT controller. Usefully the SCOOT detectors in the model can be labelled with the same reference identification as that used in the UTC SCOOT system, which makes setting up the nodes far easier that using different identifiers."

The UTC and SCOOT databases are set up exactly as they would be in a system that is used for the control of traffic. UTC functionality then allows a direct copy of the live Siemens UTC database into the off-line software – removing the need for entering the data for nodes that are already in existence.

Once the simple steps to set up Aimsun controllers and loops have been completed (and the off-line UTC database loaded) the connection between the two systems can be established. This link uses the Omni-Orb software (the .dll interface is integrated into Aimsun). "Starting the model running adaptive control is as simple as starting a new simulation," Wylie says. Functionality of UTC is retained and the standard monitoring screens can be used to check operation, SCOOT messages and the integrity of control. Using the Aimsun software it is possible to pause the model, make minor changes and then restart the simulation (including SCOOT control through the interface). "While this is a useful tool for small network amendments its suitability for substantial coding changes should be approached with caution," he does warn, however.

What a link to SCOOT allows you to achieve is an accurate representation of the adaptive signal control process, Wylie points out. "It is worth noting that linking any model to a SCOOT network that has been validated against a fixed time signals approximation may require some validation tests when the method of control is swapped," he says. "This has the potential to improve the validation confidence, especially in unsaturated conditions where it is likely that a fixed time approximation for signals calculated during the peak was inappropriate for the traffic flows. It will always be necessary to make a project by project assessment about the effectiveness of SCOOT control and any compromises that it may be necessary to make to either the simulation model – e.g. to match the database values or to the database – to tune to the microsimulation model. The scale and type of amendments needed will be unique to a project and depend on budget constraints and the scope of the project."

Looking to the future, Wylie believes that the true future use of a system appears to be bound only by processing power and the cost-benefit of investment in technology. "Once a model has been created and calibrated for a network it is the data processing required for the development of OD matrices that has the potential to slow the process," he says. "If the routing criteria are regularly assessed and updated in the model it would be feasible to input real-time flows to the model, apply real time network control interfaces and use ANPR (or similar networks) to be constantly validating and checking the model. This type of use would bring microsimulation modelling from a project based usage to an adaptive and reactive tool. The options for 'off-line work' would still exist but the 'real-time' network management function could potentially reduce congestion through integration of traffic engineering and modelling skills to test possible solutions to problems as they occurred on street and then implementing plans using the wider system tools – a fully integrated VMS network combined with SCOOT."

Working in sync with LinSig

One key element of modern traffic control modelling is interfacing the various software packages and consulant Mayer Brown, in collaboration with JCT Consultancy, has recently been working on a new software interface between widely used microsimulation modelling packages – PTV's VISSIM and SIAS's S-Paramics – and the signalised junction and network modelling package LinSig 3. The result of this work has been a LinSig–Microsimulation Toolkit (LinSig MST) to bridge the gap between these packages.

In urban transportation networks, signal timings at individual signal-controlled junctions are composed of several stages that operate cyclically, Mayer Brown's Steven Ward and Yang Li point out. When testing and designing signal-controlled junctions, one of the key aims is to coordinate timings in order to create green waves and optimise network performance and traffic flow. Signal optimisation considers traffic flows on all routes through a particular network – longer green time will accommodate larger traffic stream volumes but unnecessarily long green time not only wastes time within the cycle but also possibly reduces network performance by delaying vehicles on other routes. Empirical models such as LinSig can be rapidly developed but the results can be difficult to interpret and evaluate for the layperson. Microsimulation models can be developed alongside LinSig models to help further understand and visualise signal performance.

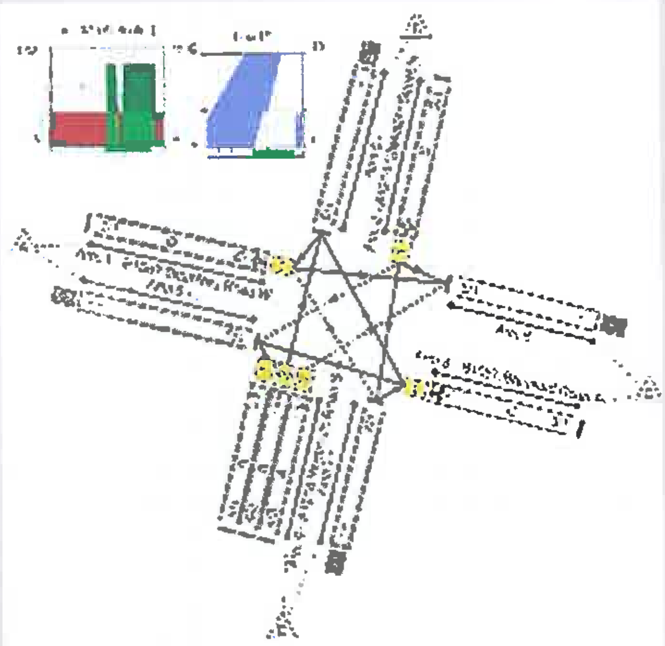
LinSig is widely used as a junction assessment tool and helps transport planners and traffic signal engineers to develop and design junctions with efficient signal settings for individual junctions and networks. LinSig consistently outputs reliable signal timings and optimisation for stand-alone junctions and networks but, Ward and Li point out, during the planning process the desire to visualise optimised signal timings and confirm network performance is commonplace for presentation to key stakeholders and at public exhibition and this can often require modellers to build two types of completely new model (LinSig and Microsimulation) and also to manually change signal timings in each.

The LinSig MST has, therefore, been developed to enable LinSig users to convert a LinSig 3 model into the popular microsimulation modelling tools PTV-VISSIM and S-Paramics. "The most obvious benefit of the MST is that it saves modellers a considerable amount of time during model development," Ward and Li claim. "Once a LinSig model has been built, calibrated and validated it is possible to automatically generate a microsimulation model based on the LinSig network layout, traffic flows and signal timings with minimal manual intervention enabling users to visualise networks and signal setting performance in a converted microsimulation model. In the future it is intended that the MST will enable users to extract and inject signal timings from LinSig into established VISSIM or Paramics models so that signal timings can be fine-tuned in LinSig and updated and reviewed quickly and economically in the microsimulation package." The MST has been developed using the Microsoft C# programming language and has a familiar Windows application style. LinSig outputs signal timings and stores network and traffic flow information in the form of an .XML file; the MST converts this information and exports it to a VISSIM or Paramics format. The conversion process is performed as follows:

Load network layout
The first step is to load the network from LinSig. In this example we use a single junction LinSig model. The example model is a four-arm signalised junction. LinSig network layouts are schematic and do not adhere to a coordinate system.

Load network layout
The second step is to load a background image file. Currently, the MST can only load background from image files but it is hoped that in the future it will be able to support scaling from AutoCAD drawings.

Align network elements
The background is used to align the key network elements. The positioning of nodes and links is the only user input required during



LinSig MST can interface with VISSIM and S-Paramics microsimulation software

conversion process and can be saved in an MST archive file.

Scale before the conversion
Before converting the LinSig network to a microsimulation model, a known distance is measured and used to scale the network.

The converted model
After conversion with the MST the microsimulation model files are created and can be opened directly in VISSIM or S-Paramics. Edits of stopline positions and kerb lines can be carried out in the chosen microsimulation tool to ensure an accurate representation of the road network.

Detailed conversion of LinSig network elements by the MST are considered as follows: links and connectors/movements in the microsimulation model are constructed based on lanes and connectors in the LinSig model; priority rules, routes, signal timings and scenarios in LinSig are used to build their counterparts in the microsimulation model; and routing flows and origin-destination zone flows in the microsimulation model are calculated based on the information of routing flows and zones from LinSig. "LinSig as a comprehensive design and modelling package for individual junctions and networks stands out among other junction and signal assessment tools," Ward and Li conclude. "Microsimulation tools such as VISSIM and Paramics are great in visualising the performance of an empirical model developed in LinSig and handling network details. However, they often incorporate a more limited specification of traffic signal issues. For this reason many authorities and consultants adopt a two-stage design process involving rapid design models to formulate options before using microsimulation to develop preferred options in detail. However, this usually means modellers need to develop two models for the same scenario."

The LinSig MST can help modellers to develop microsimulation models from existing LinSig models, however, and the converted models contain all the information in LinSig that can be applied to microsimulation models. Modellers can refine and finalise the converted models by manual adjustments and supplying other information based on their knowledge of the actual network. Therefore, the two-stage design process can be met in a much shorter time scale than previously by developing LinSig model and outputting a converted microsimulation model.