# THE TOOLS FOR TOLLS

## ANALYSIS IN A VIRTUAL WORLD

Using microscopic simulation software to model toll plazas can lead to efficiency benefits for all parties – operators, authorities and even the road users

The transportation sector is now readily adopting microsimulation traffic modeling for implementation in a wide variety of applications – and for an increasing number of projects. Although many microsimulation traffic models have been available for over a decade now, the evolution from earlier inferior modeling tools has been slow and, even after this length of time, is still a relatively new concept to many traffic modelers.

The application of microsimulation traffic modeling varies, from small localized study areas to large strategic models, and covers areas such as development control scenarios, local plans, master plans and strategic corridor-management plans. As roads have become more congested, existing capacity needs to be managed more effectively, as opposed to creating more capacity. The use of ITS has increased to maximize capacity usage, so it is now necessary for traffic modelers to adapt and embrace the challenges of modeling, enabling them to investigate corridor-wide management strategies, including the need to model systems such as ramp metering, HOV and HOT lanes and now toll plaza facilities.

by Richard Braidwood

## ROAD PRICING/TOLLING

Charging vehicles to use roads – whether for a specific lane or at a plaza for using a route – is widespread across the USA, Europe and Australasia. Funding for these schemes is regularly financed from the public purse or gasoline taxes, but in regions around the tolls, they have been an effective way of raising revenue to develop road infrastructure.

The first turnpikes/toll roads in the USA that assisted opening the Midwest to settlement were built in the 1970s. Many of these turnpikes or toll booths have helped to raise revenue to develop the now extensive Interstate network across the USA.

The disadvantage of toll booths that employ traditional payment methods is that during heavy traffic conditions drivers are subjected to delay. Even when electronic tolling is adopted at toll plazas, poor toll approach lane definition and lack of capacity for particular payment types can cause unnecessary vehicle lane changing. Over-capacity at plazas ultimately reduces the efficiency of the facility and therefore causes delay to drivers. The adverse effect of this is that toll operators and local authorities lose revenue – not to mention the economic cost to society as a result of lost time and the environmental impact of emissions generated by slow-moving and stationary traffic.

Authorities in the USA and Australia are now successfully applying microsimulation traffic modeling technologies in their assessment of existing and proposed toll plaza facilities.

## TOLL PLAZA OPERATION

The design of toll plazas is complex and the implementation of plaza facilities expensive. Toll plaza and toll road construction costs can be 10% greater in design and build cost than a traditional freeway due to construction standards and additional infrastructure needs, such as the gantries themselves. For this reason, optimal design is important: a poorly designed or optimized toll booth can create greater delay for road users and reduce the potential revenue for toll operators. The use of microsimulation modeling can assist at the design stage of a new toll plaza and can be used to optimize existing plazas.

**"A POORLY DESIGNED OR OPTIMIZED TOLL BOOTH CAN CREATE DELAY FOR ROAD USERS AND REDUCE REVENUE FOR OPERATORS"**

The development of a microsimulation traffic model allows for sensitivity tests in new or existing toll plazas. Scenarios can be undertaken to estimate the potential delay that may or may not occur if different profiles of payment are made from one day to the next. How would the facility cope with increased traffic demand? If the toll facility can service high volumes of traffic, how does that impact once the traffic has passed through the toll plaza? Will an increase in electronic payment users increase the throughput at the plaza and therefore reduce delay to road users?

Microsimulation is a useful tool for the tolling industry. This image shows a 2D view of a toll plaza, demonstrating the delay that is caused to those drivers who are using traditional payment methods

## MODELING TOLL PLAZAS

A variety of toll booth types are found at many plazas and generally these consist of cash-only lanes (which can be automatic or manual) and electronic payment (which in some cases still require the driver to stop while the payment is made). Payment can be made by credit card, cash, pre-payment cards, or electronically.

A challenge faced by traffic modelers when developing models of toll plazas has been the constraints of the different software packages, which do not provide the flexibility to accurately model the delay created by payment methods or provide detailed output data.

To satisfy the demand for modelers to accurately model toll plazas, software developers are developing tools that model the key elements that make up a toll plaza more accurately. Such key elements that need to be incorporated when developing a microsimulation model of a toll plaza model include: the approach lane usage; the toll booth payment types; variation of stop-time profiles at each toll booth; and the lane usage at the merge after the toll booth.

## DEFINING TOLL BOOTH TYPES

The chosen microsimulation modeling tool for a toll plaza project should provide the facility for the traffic modeler to define a single payment type, or a combination of payment types for each booth (a booth is represented by a lane). This is normally achieved by firstly allowing the user to model vehicle classes by payment type, and then apply a vehicle-class restriction to control which booth a vehicle can use based on its payment type. This is the first step in defining what lanes the vehicles approaching the toll plaza can use.

## STOP-TIME PROFILES

The most important aspect when modeling a plaza is to define stop-time profiles. In the first instance, the tools available to modelers provide the capability to model different stop-time profiles for individual payment types/toll booths. Secondly, they provide the ability to apply variation in stop-time profiles for each payment type/toll booth: i.e. 30% of drivers 'paying manually requiring change' will incur 12 seconds delay, 10% will incur 17 seconds delay, etc.

This image portrays a 3D toll plaza with multiple toll booths. When modeling plazas with multiple booths, looking at approach lane definition is crucial

This detailed modeling of vehicle stop times ensures the delay modeled is as accurate as possible. Such a facility – one of the most important elements of modeling toll plazas effectively – is not available with all microsimulation traffic modeling tools. Other solutions may use a much more coarse method of applying an average stop line for all toll booths, which renders them unsuitable for the detailed analysis.

## OUTPUT DATA

The ability to accurately model toll plaza facilities is important and the benefits of the visual output provided by microsimulation traffic models is essential, particularly when communicating a concept to non-transport professionals.

The visual output, however, is only relevant if comprehensive toll plaza statistics cannot be collected from the model. The investment in developing a simulation model for such a study could be questioned if strong statistical output cannot be provided. For microsimulation products that provide detailed statistical output data, there are obvious advantages.

Toll plaza-specific output data that is currently available in some microsimulation models for each individual toll booth includes: headway; throughput, wait time, queue time; and unoccupied time.

The output information can be collected for varying time intervals and allows the traffic microsimulation modelers to undertake statistical analysis between different design scenarios using accurate and focused data for the plaza facility, rather than assessing overall model statistics that may be influenced by 'noise' from other areas of the modeled study area.

While traditional traffic modeling softwares do not have the ability to model the complex vehicle behavior at toll plazas, new products equipped with these capabilities are starting to enter the market

**"THE MOST IMPORTANT ASPECT WHEN MODELING A TOLL PLAZA IS THE ABILITY TO DEFINE STOP-TIME PROFILES"**

## CONCLUSIONS

It should be noted that a microsimulation traffic model cannot be used to determine the optimization of the payment mix for overall design for any given toll plaza.

However, the application of microsimulation traffic modeling plazas can accurately provide a valuable insight into the potential effects of changing the mix of payment methods, or the overall design of an existing toll plaza or proposed toll plaza design. It can also be used to access design changes prior to expensive implementation or provide valuable information that may lead to more efficiency at the toll plaza, providing benefits for all parties – improving revenue streams for toll plaza operators and local/state authorities and reducing overall delay for the road users using the facilities.

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