THE ADVANTAGES OF MICRO SIMULATION IN TRAFFIC MODELLING WITH REFERENCE TO THE N4 PLATINUM TOLL ROAD

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ABSTRACT

Micro simulation has been used to a limited extend in the past in South Africa, despite major advantages of this tool above static modelling and it's popularity oversees. The main advantages are dynamic modelling and visual interpretation of the traffic conditions. This tool is ideal to test geometric designs, traffic controls and a variety of traffic management measures. These include incident and congestion management, road works, ramp metering, VMS, etc. It is an extremely suitable tool to use when low cost solutions must be found because of severely limited infrastructure resources. Times that micro simulation was not able to calculate and show reliable traffic situations is over, various traffic simulation models have developed and have reached high quality standards. Micro simulation is about to gain a real market share all around the world; South Africa is following.

Modelling toll plazas at interchanges on the N4 Platinum Toll Road is used to illustrate the advantages of micro simulation. Geometric design options, measures effecting toll throughput and traffic control options were evaluated in this example as well as the estimation of the expected life span of various options within a congested network. The package used in this study is AIMSUN2, an advanced micro simulation package widely used internationally that can interact with TRANSYT, SCOOT, EMME/2 and SATURN. AIMSUN2 has been applied to traffic impact analysis, traffic control measures, HOV-lanes, tolling and geometric design within the last three years in South Africa. It has also been used successfully to convey results of investigations to non-technical people.

1. MICRO SIMULATION

1.1 Background on the development of micro simulation

The microscopic traffic simulation models are based on the reproduction of the traffic flows simulating the behavior of the individual vehicles, this not only enables them to capture the full dynamics of time dependent traffic phenomena, but also to deal with behavioral models accounting for drivers' reactions. The underlying hypothesis is that the dynamics of a stream of traffic is the result of a series of drivers' attempts to regulate their speed and acceleration accordingly with information received. The driver's actions resulting from the interpretation of the information received will consist on the control of the acceleration (braking and accelerating), the control of heading (steering) and the decision of overtaking the precedent vehicle either to increase the speed or to position themselves in the right lane to perform a maneuver (i.e. a turning).

The origins of microscopic traffic simulation can be traced back to the early stages of digital computers. Although the basic principles were set up many years ago, with the seminal work of, among others, Robert Hermann and the General Motors Group in the early fifties, the computing requirements made them impractical until hardware and software developments made them affordable even on today's laptop computers.

Most of the currently existing microscopic traffic simulators are based on the family of car-following, lane changing and gap acceptance models to model the vehicle's behavior. Car-following models are a form of stimulus-response model, where the response is the reaction of the driver (follower) to the motion of the vehicle immediately preceding him (the leader) in the traffic stream. The response of the follower is to accelerate or decelerate in proportion to the magnitude of the stimulus at time t after a reaction time T. The generic form of the conceptual model is:

$$\textbf{\textit{response}}\ \mathbf{(t+T)} = \textbf{\textit{sensitivity}} * \textbf{\textit{stimulus}}\ \mathbf{(t)}$$

Among the most used models are Helly's model (1), implemented in SITRA-B+, (2), Herman's model (3), or its improved version by Wicks (4), implemented in MITSIM, (5), the psycho-physical model of Wiedemann, (6), used in VISSIM (7), or the ad hoc version of Gipps (8), used in AIMSUN2 (9, 10). Other microscopic simulators such as INTEGRATION (11) and PARAMICS employ heuristic or other modeling not publicly available in analytic form.
A common drawback of most of these models is that the model parameters are global i.e. constant for the entire network whereas it is well know that driver's behavior is affected by traffic conditions. Therefore a more realistic car-following modeling for microscopic simulation should account for local behavior. This implies that some of the model parameters must be local depending on local geometric and traffic conditions.

1.2 What micro simulation is and the advantages thereof compared to static models

The deployment of Intelligent Traffic Systems (ITS) requires support of complementary studies clearly showing the feasibility of the systems and what benefits should be expected from their operation. The large investments required have to be justified in a robust way. That means feasibility studies that validate the proposed systems, assess their expected impacts and provide the basis for sound cost benefit analyses. Microscopic traffic simulation has proven to be a useful tool to achieve these objectives. This is not only due to its ability to capture the full dynamics of time dependent traffic phenomena, but also being capable of dealing with behavioral models accounting for drivers' reactions when exposed to ITS systems.

The advent of ITS has created new objectives and requirements for micro-simulation models. Quoting from Deliverable D3 of the European Commission Project SMARTEST [12]: "*The objective of micro-simulation models is essentially, from the model designers point of view, to quantify the benefits of Intelligent Transportation Systems (ITS), primarily Advanced Traveler Information Systems (ATIS) and Advanced Traffic Management Systems (ATMS). Micro-simulation is used for evaluation prior to or in parallel with on-street operation. This covers many objectives such as the study of dynamic traffic control, incident management schemes, real-time route guidance strategies, adaptive intersection signal controls, ramp and mainline metering, etc. Furthermore some models try to assess the impact and sensitivity of alternative design parameters*". The analysis of traffic systems and namely ITS systems, is beyond the capabilities of traditional static transport planning models. Microscopic simulation is then the suitable analysis tool to achieve the required objectives.

An example from a real case study where microscopic simulation was used to complement static modeling will help us to understand better how both levels may help the decision-maker. The city of San Sebastián, in the North of Spain, completed recently a new urban freeway connecting two separated neighborhoods. Figure 1 shows the typical result of the planning study with an close up of the Amara neighborhood. The road network and the demand were modeled using the EMME/2 package. The figure displays the expected impacts of the new infrastructure highlighting in green the average flow reduction due to the redistribution of flows enabled by the new paths on the network, and in red the increase of flows attracted by these paths. A significant discharge in the level of congestion in the main road network was the foreseen impact of the new infrastructure, but the access to the new freeway in the East-West direction shows some undesirable side effects in the neighborhood (Amara) inside the rectangle. The solutions to these problems demands a close up to the sub-network and take decisions at the level of traffic control and traffic management schemes, not excluding even a partial reshaping of part of the street network. This type of decision requires a more detailed modeling, able of reproducing in a very accurate way the traffic conditions, accounting for the interactions between the vehicular flows and the infrastructure, and obviously including the influence of the traffic lights, objective that can only be achieved by a microscopic traffic simulation model.

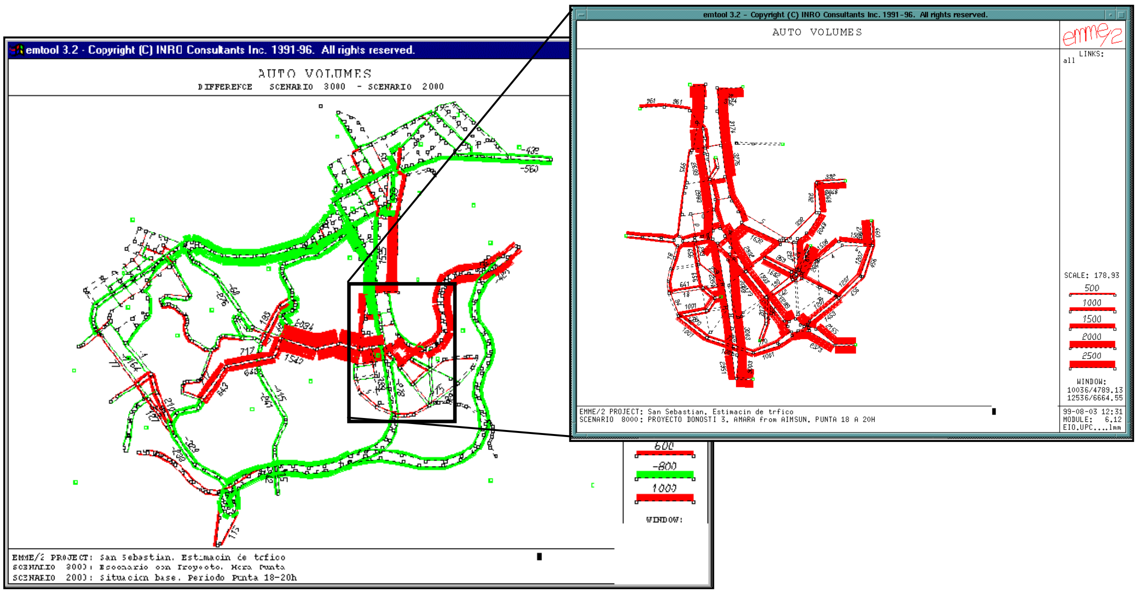

Figure 1: Expected impact of the new infrastructure in San Sebastián with an close up of the Amara neighborhood

Figure 2 displays the corresponding model built with the AIMSUN2 traffic simulation software, the EMME/2 sub model has been built automatically from the AIMSUN2 model by means of an interface between both systems.

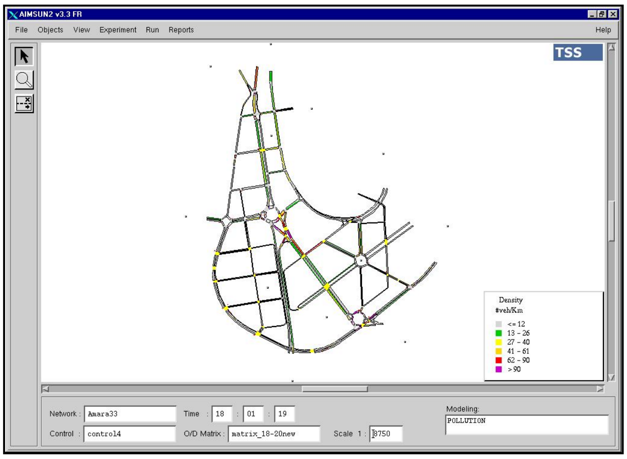

Figure 2: AIMSUN2 micro simulation model of the Amara neighborhood

The type of information that micro simulation can provide for a further analysis is beyond the capabilities of traditional static models. The average flows from sections to sections turning movements) for the allowed movements at selected intersections in the model, speeds and delays for every simulated time interval can be obtained. The dynamic analysis for a time period is completed with values for other traffic variables or indicators of the quality of service as number of stops, time delayed at stops, average queue lengths, etc.

Figure 3 provide a further insight on the capacity of analysis provided by dynamic simulation software. The graphic in this figure describes the evolution over time of average flows. The same type of graph can be produced for average queue lengths on a subset of selected sections in the model.

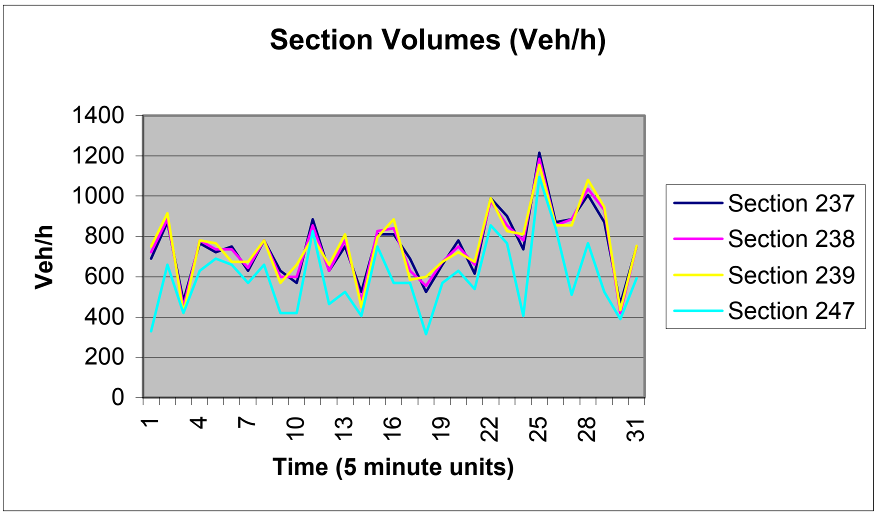

Figure 3: The evolution of average flows over time

1.3 The ease of model building and data input (AIMSUN2)

The recent evolution of the microscopic simulators has taken advantages of the state-of-the-art in the development of object-oriented simulators, and graphical user interfaces, as well as the new trends in software design and the available tools that support it adapted to traffic modeling requirements. A proper achievement of the basic requirements of a microscopic simulator implies building models as close to reality as possible. The closer the model is to reality the more data demanding it become. This has been traditionally the main barrier preventing wider use of microscopic simulation. Manual coding of geometric data, turning movements at intersections, timings and so on, is not only cumbersome and time consuming but also a potential source of errors. It is also hard to debug if the appropriate tools are not available.

A way of overcoming these drawbacks in AIMSUN2 has been to provide the micro simulator with proper user friendliness based on the versatility of traffic network graphical editors. With this purpose AIMSUN2 is imbedded in GETRAM (**G**eneric **E**nvironment for **TR**affic **A**nalysis and **M**odeling), a simulation environment inspired by modern trends in the design of graphical user interfaces adapted to traffic modelling requirements. TEDI is the set of graphical tools which can import the geometric background of the road network to draw the network model on top, as shown on the left part of Figure 4. The background can be imported as a .dxf (or any other graphic format) file from a CAD or GIS system. All objects comprising the road model can be built with the graphic editor. Their attributes and parameters are defined and assigned values by means of windows dialogues such as the one in the right part of Figure 4, which shows the definition of the shared movements in a phase of a pre-timed signal control, and the allocation of the timings. Summarizing, these software environments for traffic modeling make an easy task of the model building process, ensure accurate geometry, prevent errors and provide powerful debugging tools.

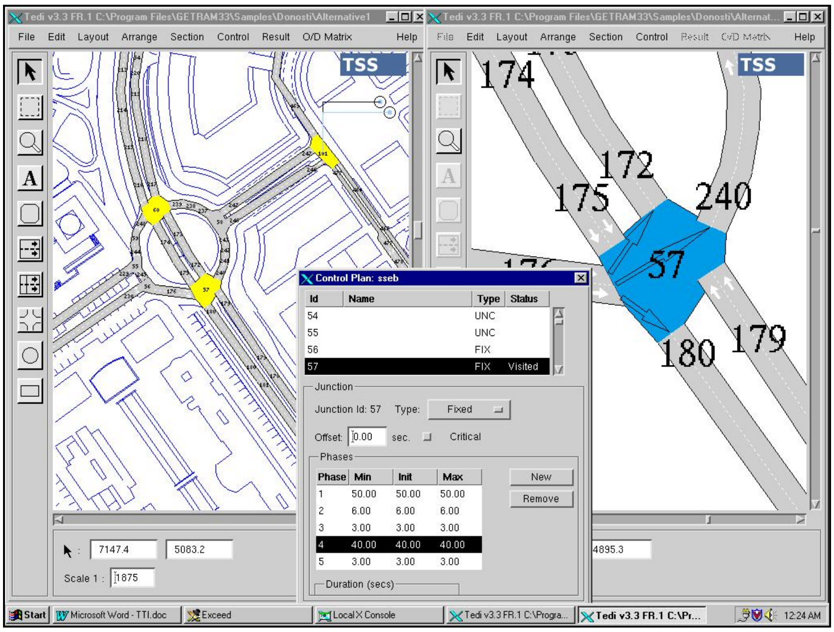

Figure 4: Example of graphic user interface for building microscopic simulation models.

1.4 AIMSUN2 as an example of the wide field of application

- **ISM** (Intermodal Strategy Manager): GETRAM has become a key component of this tool created as a project by the **German Hessian Road and Traffic Authority**. An off-line component is used as a laboratory to simulate and evaluate the impact of intermodal strategies. These optimised strategies are then downloaded to the on-line ISM which manages those strategies on real time depending on the traffic conditions.
- **Lisbon** (Expo'98): development of a model of a wide area around the world exhibition centre for a study of the access, the appropriate traffic management measures and the evaluation and design of the necessary new infrastructure.

- **Mecca**: Study for the optimisation of the transport routines and bus organisation for the yearly days of pilgrimage to Mecca, during which 2.000.000 people travel all together to the same places.
- **Capitals**: Decision support system for **Madrid's city centre** traffic control unit. Several simulations are run in parallel several times faster than real time with on line information from the traffic detectors. One simulation runs with the present control plan while the rest runs with a set of control plans selected from a general library. An alternative control plan might then be proposed to the control unit manager.
- **Pata Sur**: Important new infrastructure had to be built at **Barcelona's southern vertex** to intercommunicate three different freeways to improve the access to the city and establish a direct route to the airport. Static traffic assignment reveals the efficiency for two alternatives. This problem was overcome by micro simulation with a more sensitive dynamic peak hour evaluation was done.
- **PRIME Project** (Prediction of Congestion and Incidents in Real Time, for Intelligent Incident Management and Emergency Traffic Management) of the IST Programme, consists of developing models of incident probability to estimate the likelihood of occurrence of incidents in real time. Output from the models are then used to support traffic management decisions that seek to reduce the probability of incident occurrence.
- **New Zealand**: This is a major vehicle emissions policy study for the New Zealand Ministry of Transport. The GETRAM Extensions module was used in conjunction with a static model to forecast pollution levels in airsides around major traffic corridors.

1.5 AIMSUN2 as an example of the accuracy that can be achieved

Once the quality of the network and traffic control modeling has been assured with the help of TEDI the next point is to guarantee the quality of the car-following, lane change and other behavioural models. The AIMSUN2 car following model has evolved after the seminal Gipps model, which was improved to meet the local requirements, described earlier. Various aspects of the model have been enhanced based on the empirical evidence gathered calibrating the models for observed data:

- The way in which the vehicle speed V*(n) used in the Gipps model is calculated, accounting for local effects in some circumstances.
- How vehicles in adjacent lanes influence vehicle's behavior.
- Accounting for grade effects in car-following
- The decision process emulating driver's decision in overtaking maneuvers, including look-ahead abilities to consider the convenience of positioning the vehicle early in advance in the right lane when necessary.

Details on the improved modeling can be found in (13), or visiting the web page http://www.tss-bcn.com. The accuracy that can be achieved with AIMSUN2 can be made apparent analyzing two main aspects: the accuracy that can be achieved in calibrating the internal model parameters if the required information is available, and the accuracy that can be achieved in validating a model.

1.5.1 Calibration of AIMSUN2 car-following model

To quantify the quality of internal modeling in AIMSUN2, in addition to numerous tests performed by the research team, the car-following model in AIMSUN2 has been tested and calibrated in various real life projects, but of special interest are the results from the benchmark test performed based on the data and the methodology supplied and proposed by a research group from Robert Bosch GmbH (14). This test employed a set of field data and most of the micro simulator developers in Europe and North America were invited to participate. The test for the car-following model was defined as follows:

The primary task of a car-following model is to reproduce realistic car-following behavior. The reality has been measured with a radar sensor equipped vehicle recording distance and relative speed to the front car (additionally to the own car's speed) in a 100 ms cycle, see (15) *for further details. One specific sequence of 5 min length has been chosen to perform the comparison. This sequence has been recorded under stop&go conditions during an afternoon peak on a one-lane-per-direction fairly straight road in Stuttgart, Germany. Stop&go is most challenging to the models because the free flow behavior is relatively easy reproducible by any model. During the 5 min sequence several decelerations and accelerations of the front car have been observed. At one moment after 144 sec the front car turned off resulting in a distance step of about 40 m. Because such a maneuver can always happen in real traffic the models have to be able to deal with. Note that it can't be the target of a simulation model to reproduce exactly the measured behavior of this specific driver in the specific test vehicle. Driver and vehicle variations have to be respected. Hence, the main focus lies on qualitative differences. But the fairly good reproduction of the behavior indicates a model's realism. To give an impression of similarity to the measured behavior a quantitative error metric on the distance seems to be reasonable. To avoid overrating discrepancies for large distances a relative metric was chosen weighted by the logarithm and squared. Only the values after each second have been considered*".

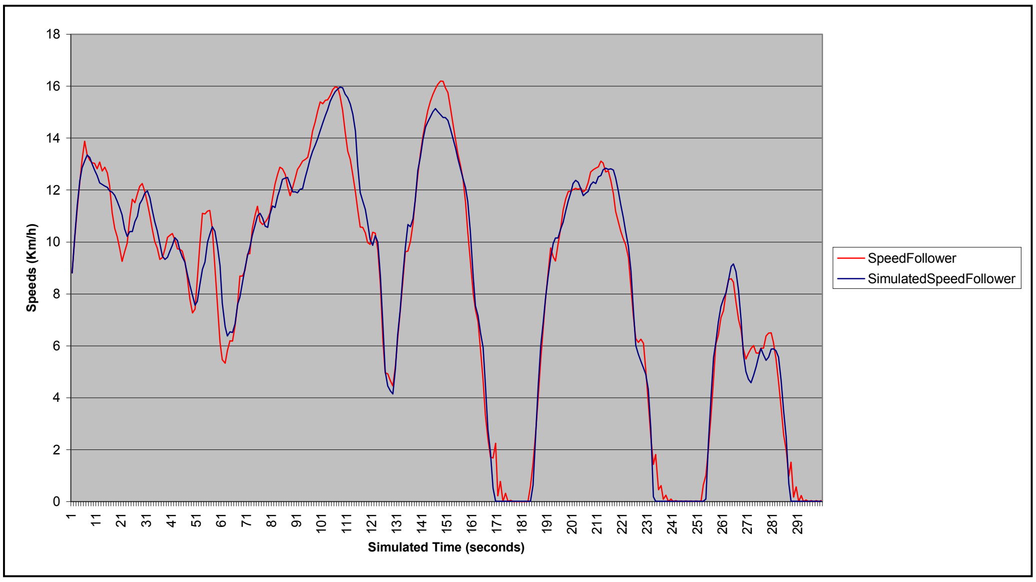

Figure 5. Measured and Simulated Speeds

The error metric used to measure the accuracy of the fitting between measured and simulated values was: $Em = \sqrt{\sum \left[\log\left(\frac{d\_sim}{d\_meas} \right) \right]^2}$ where *d_sim* is the distance of the simulated vehicle, *d_meas* is the distance measured with the test vehicle, and *log* denotes the logarithm base 10. Figures 6 and 7 display the curves for the observed versus simulated relative distance and speed between leader and follower. The numerical value for the error metric for the AIMSUN2 model was 3.4726. These results show that the AIMSUN2 car-following model is able of a fairly good reproduction of the observed values. The numerical value of the error metric outperforms those provided for most of the currently used models as the following table from (15) shows:

Model	MITSIM	Wied/Pel	Wied/Vis	NSM	OVM	T^3M
Deviation	3.75	14.01	10.67	24.51	9.37	2.40

(MITSIM is the MIT micro simulation model, (5), Wied/Pels and Wied/Vis stand for the Wiedeman's models implemented in VISSIM, (6) and (7), NSM corresponds to the cellular automaton model in TRANSIMS, and OVM and T^3M are models referenced in (15))

An additional test to analyze the quality of the microscopic simulator is to check the ability to reproduce macroscopic behavior. Also the research team at Bosch proposed in (15) a test to compare various microscopic simulators: "*The macroscopic behavior of a microscopic model can be most easily tested by simulating the traffic on cyclic one lane roads. This excludes any effects of lane changes and node passing and concentrates on the car-following task. For this study, a cyclic road of 1000 m length was used. A fixed number of vehicles has been initially set with speed value 0 km/h at randomly determined positions. All vehicles had the same length of 4.5 m and the drivers had the same free flow speed of 54 km/h. Starting with this initial situation a 10 minute time period was simulated without any measurements to reach traffic conditions which are achievable by the model's behavior itself. After the starting phase the traffic behavior has been recorded at one local measurement point during a simulation time of 2 hours (exact passing time and speed value of each vehicle). The fixed number of vehicles for the simulation run was varied in discrete steps to realize different traffic densities. To visualize the results the traffic flow has been drawn versus the density (given as the number of initially set vehicles on the 1 km ring). The maximal mean traffic flow value of about 1800 veh/h is known as a quite realistic value for longer periods of measurement time. Under urban traffic conditions this maximal flow is typically reached at higher density values than for freeway traffic*".

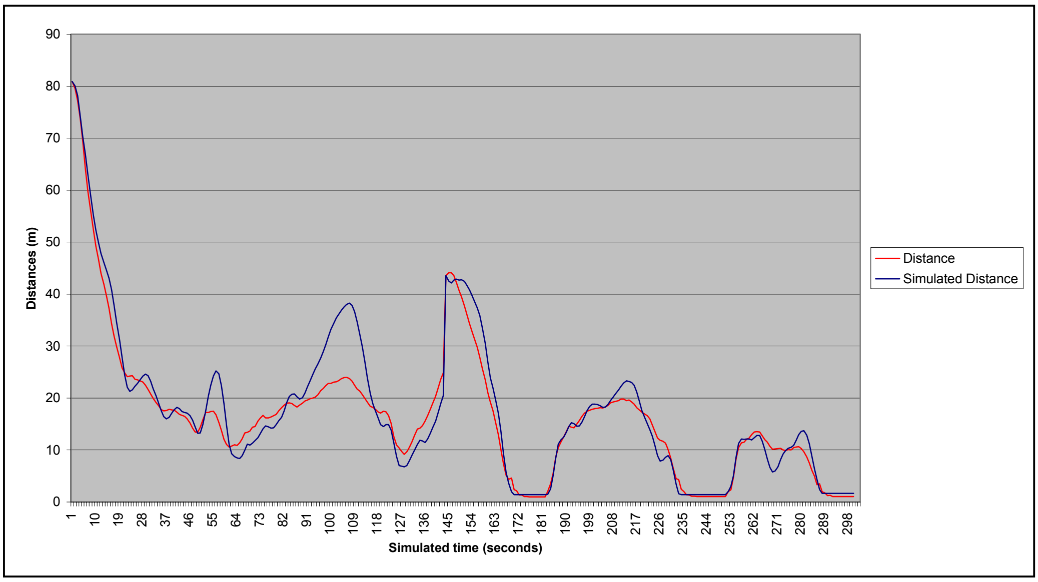

Figure 6. Measured and Simulated Distances

The results of AIMSUN2 for the simulated flow density curve versus the empirical one for the second test are displayed in figure 7, and they appear to be fairly reasonable. This subjective perception is confirmed by the values of the error metric to measure the fitting between the measured and simulated values as before, that in this case is *Em*=0.063381.

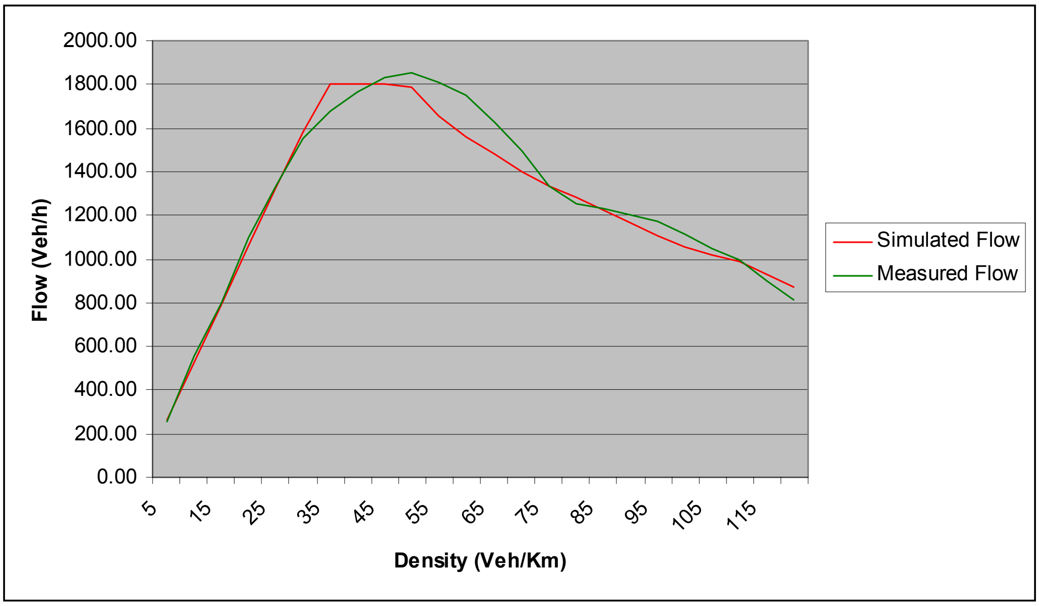

Figure 7: Empirical versus simulated flow-density curves

1.5.2 Model validation

The first step in a simulation study, once the simulation model of a scenario has been built, before using it for sophisticated applications, is to prove that it can reproduce to an acceptable degree of significance the observed traffic conditions or, in other words, that it is capable of emulating the reality with enough accuracy. The calibration and validation of the simulator are the required proofing exercises.

A feasibility study (16) on the suitability of integrated ramp control strategies on a segment of the I-35W in Minneapolis is used as an example for validation. A validation exercise typically consists (17), (18) of the statistical analysis comparing the observed with the simulated values, and changing the simulation parameters until the statistical test achieve what the analyst could consider and acceptable degree of significance in the similarity of both series. In the case of the Minnesota study referenced above the exercise consisted in the comparison between the simulated and the observed values for flow measurements on the 60 detection stations along the freeway segment under study. The graphical comparison between the Observed and the Simulated flows measured every five minutes over the simulation horizon of six hours for one of the detectors is depicted in Figure 8.

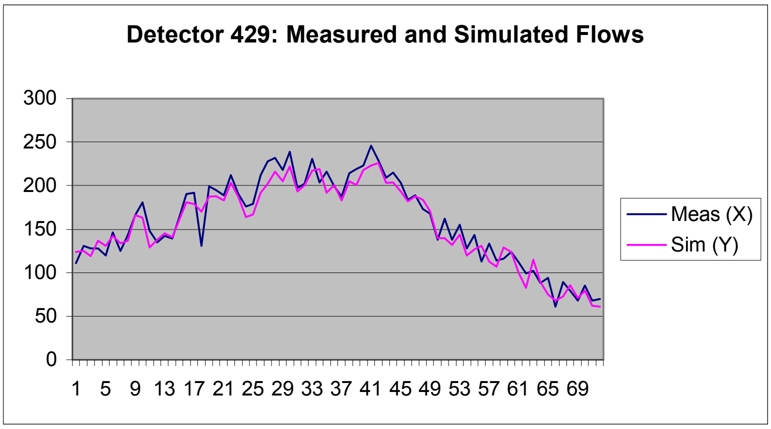

Figure 8: Measured vs. simulates flows

Various tests can be applied to determine the accuracy of a model. The or root mean square percentage (rmsp) error in the case of the Minnesota study has a value of 0.0877, which is quite close to zero. More refined techniques like the paired T-Test and confidence interval give a mean difference of 5.10 with an standard deviation of 11.50 and a p-value of 0.00. We should therefore conclude that both series are not identical, however, a less restrictive test as the two sample T-Test and confidence interval gives a p value of 0.52, showing an high level of similarity. This is confirmed by the regression analysis that gives the regression equation y = -01787 + 1.03813 x, with a p value of 0.00 for the regression coefficient and a $R^2 = 0.947$.

The visual inspection of both series reveals a high degree of agreement, so far confirmed by the above results, but to be sure it would be convenient to use a technique of comparison of both series, considering them as time series that considers the potentially disproportionate weight of large error. This is the type of information that provided by Theil's coefficients (18). In our example the respective values are: $U = 0.038169$, $U_M = 0.166091$ and $U_S = 0.061009$, and therefore we can conclude that the simulation model is replicating acceptably well the real system.

2. N4 PLATINUM TOLL ROAD

2.1 Main reasons for choosing micro simulation for the analysis of traffic conditions

The N1 is the most important north-south link between areas to the north and south of the Magaliesberg in the east of Pretoria and because of that traffic volumes increased to such an extend that **heavy congestion** occurs on this part of the network during both the morning and afternoon peak periods. Congestion occurs on Zambesi Road at the Zambesi interchange, the N1 between Zambesi and Proefplaas interchanges and Stormvoël Road at Stormvoël interchange.
Proposed changes to a road network under such congested conditions will not only have localized impacts, but will have impacts (positive or negative) on traffic elsewhere on the network. It is thus important to be able to **determine the wider effect of proposed changes to the network**.

The **results of the investigation were communicated to a wide spectrum of persons** that includes not only Engineers familiar with the technical terms and criteria of evaluation, but also to persons in other professions not familiar with the technical terms and criteria of evaluation. It is much easier to get the message across when it is possible to visually show the expected conditions. Most people can relate to a birds eye view video presentation of the expected results.

South African National Roads Agency's (SANRA) **requirements and the risks** involved for the Bakwena Concessionaire calls for an evaluation tool that are capable of simulating traffic conditions realistic. AIMSUN2 simulates the behaviour of each individual vehicle, including manoeuvres such as overtaking, weaving and car following, which is crucial when various options are evaluated within congested conditions.

2.2 Requirements laid down by SANRA

2.2.1 LOS requirements for intersections

SANRA required that the LOS of any particular lane group of signalised intersections in an urban area **should not get worse than LOS_D**. The measure of effectiveness in this instance is the Level of Service (LOS) applicable to signalised intersections in an urban area, which is based on the average stopped delay and/or volume to capacity ratio per lane group.

It is quite easy to determine whether the Bakwena Concessionaire adheres to this requirement or not. Existing static evaluation methods can be used or micro simulation. Network wide impacts of proposed changes and the various responsible bodies involved tipped the scale towards micro simulation.

2.2.2 LOS requirements for toll lanes

The requirements for toll plazas are different from that of intersections in an urban area and the measure of effectiveness is specified in terms of the average service time (which should not be longer than 30 seconds) and the occurrence of queues, which is described as follows:

*"When **20 random observations** are made during any 60 minute period the maximum number of vehicles queuing shall not exceed more than once the value of 6 multiplied by the number of open lanes."*

Random observations accommodate the dynamic nature of queues. With micro simulation one can collect queuing information for almost any specified time interval. It is thus possible to collect the information for very short time periods and do a random selection, which represents the random observations.

2.3 Micro simulation model

The AIMSUN2 model consists of four main parts:

1. Network
2. Traffic control
3. Origin-destination matrix
4. Vehicle characteristics

The **network** is in great detail and consist of the correct location of intersections, number of lanes (including lane widths) and lane layouts at intersections (including the length of slip lanes) as depicted in Figure 9. The network covers the N1 from Proefplaas interchange to Zambesi interchange with sections of both Zambesi and Stormvoël Roads to the east and west of the N1.

Correctness of the network regarding the location of intersections and the distances of road sections was achieved by using the Pretoria City Council's GIS as background during the building of the network. A survey of the lane layout at intersections was also done.

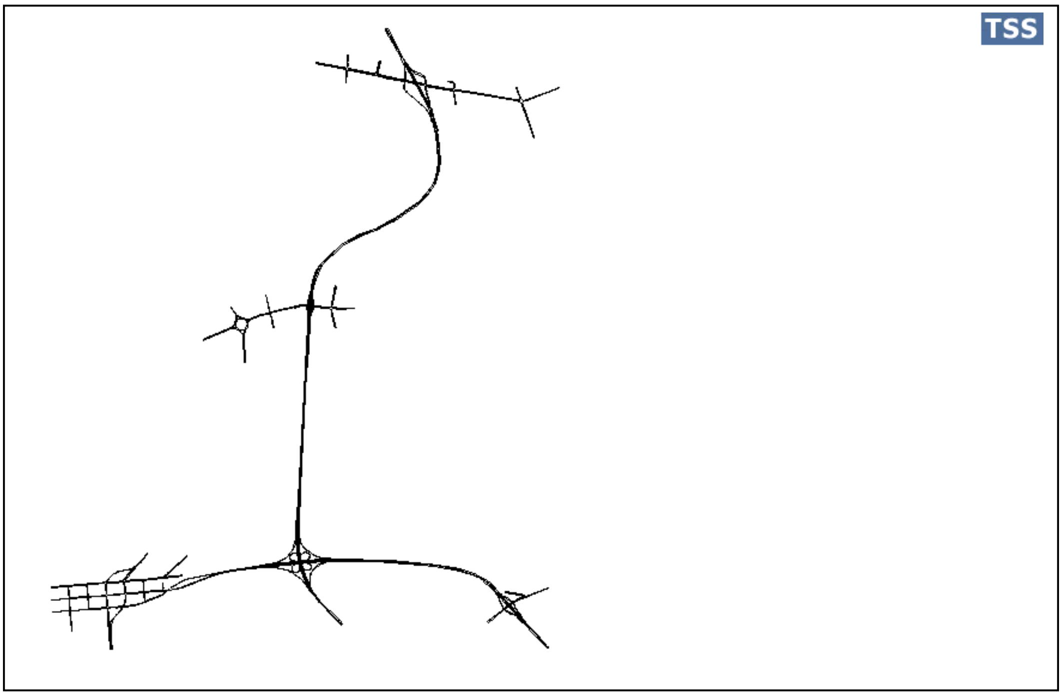

Figure 9: Network used in the AIMSUN2 model

Traffic control data includes both the type of control (priority or signalized) and the traffic light settings for the period to be simulated. This information could be obtained at local authorities.

Origin-destination matrix was obtained from the audited BAKWENA SATURN model and was adjusted for AIMSUN2 according to existing counts. The matrix was divided between 15-minute time intervals and covers the morning peak period.

Vehicle characteristics consist of vehicle dimensions, acceleration and deceleration rates as well as other parameters describing driver behaviour to a certain extend.

The model was **calibrated and validated** against the same counts that were used for the BAKWENA SATURN model. Satisfactory results were obtained as shown in Figure 10. The coefficients of the curve fitted (y = a + bx) by means of the least square method are as follows:

- a = -28.539
- b = 0.932
- R^2 = 0.954

Figure 10: Modeled volumes versus traffic counts

2.4 Testing of alternative layouts and the development of cost-effective improvements

The base year model clearly reveals that the west to east traffic experienced the greatest delays and that solutions must be focused on this movement. There are however two important external factors affecting this movement. That is the N4 Platinum Toll Road, which will attract through traffic from Zambesi Road and the tolling of the southern ramps. The combined effect of these two factors is a reduction in the west to south traffic and a slight increase in the west to east traffic at Zambesi interchange. Alternative options have to be evaluated within this context and **improved traffic light settings** for each option has to be determined as well as the **impact of excessive delays at adjacent intersection** on the Zambesi interchange. The later requires that the model must assist in the identification of bottlenecks, which could be done with ease.

Three alternative options for the Zambesi interchange were evaluated (Figure 11), these are:

- Option 1: Local improvements to the existing layout, which includes extended right turn slip lanes and optimized traffic light settings. This option offers a 67% reduction in the average stopped delay per vehicle compared to the base year situation. A Rate of Return in excess of 5000% is achieved with this option.

- Option 2: Construction of a loop in the north-east quadrant for west to south traffic to divert the west to south traffic from the eastern ramp terminal. Savings in stopped delay for this option is almost the same as for option 1, but the construction cost is much more therefore the low internal rate of return of 172%.

- Option 3: Provision of a directional link to accommodate west to south traffic. This traffic is taken out of the system thus the 83% reduction in average stopped delay over the base year, but the high cost of this alternative gives a Rate of Return of only 163%.

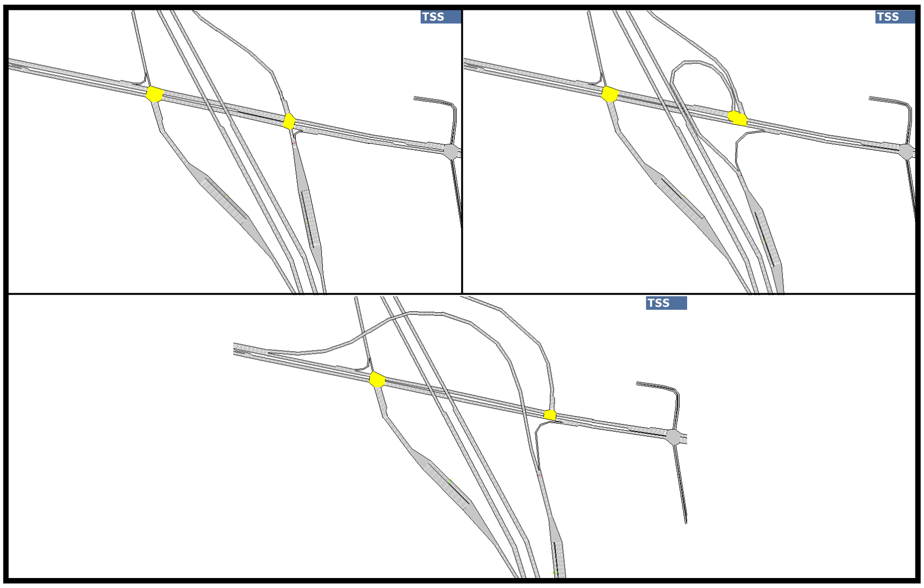

Figure 11: Three alternative layouts for Zambesi interchange

It is important to realize that the above reductions in delays was calculated within the context of the network as a whole and not by isolating intersections.

2.5 Testing of toll plaza layouts

The first reaction to the proposed toll plazas is that it will increase the delays at Zambesi interchange to such an extent that the whole system could clog. This reaction is based on the delays to be caused at the toll plazas and the very short distance between the toll plaza and the intersection for the southbound movement.

It is thus very important to be able to determine the impact of the combinations of various pay methods (manual, card and ETC) and the configuration of the toll lanes. The combination of pay methods affects the delays at the toll plazas, while the lane configuration affects the weaving, which is of utmost importance because of the short distance between the toll plaza and the intersection.

Various options have been tested and the final option was evaluated not only for the base year morning peak period, but also for the afternoon peak period as well as for 2003 (with and without the N4 Platinum Toll Road in place). The expected queue lengths during the morning peak period are shown in Figure 12.

2.6 Communication of results

The results of the investigation were communicated by means of the graphs and tables and by running the model. We have found that both engineers and non-engineers prefer to see the simulation and then relate the visual images to the figures in the tables and graphs. Micro simulation models are therefor a powerful tool to use in presenting the results of investigations.

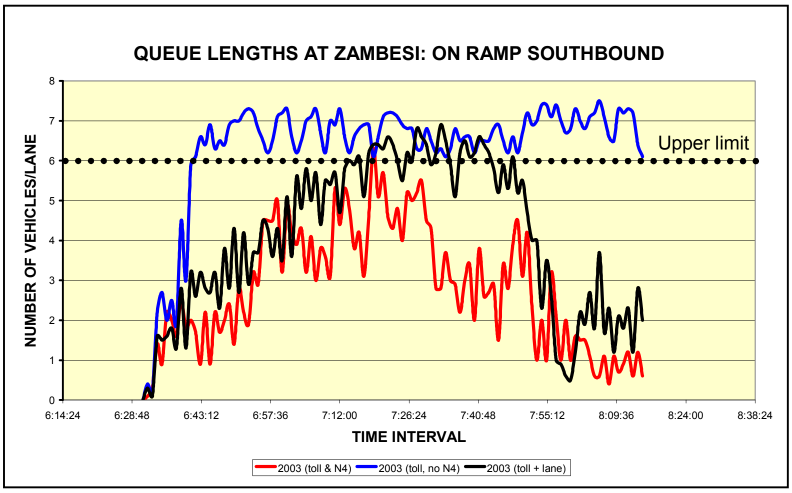

Figure 12: Expected queue lengths at Zambesi southbound toll plaza

2.7 Conclusion

Microscopic traffic simulation has proven to be a useful tool to achieve the goal of testing intelligent Traffic Systems, due to its ability to capture the full dynamics of time dependant traffic phenomena and its capability to deal with behavioral models accounting for drivers' reaction when exposed to ITS systems.

It is clear from the use of AIMSUN2 that micro simulation models have been used quite extensively for various purposes, which includes the evaluation of the impact of intermodal strategies, traffic management measures, evaluation & design of infrastructure, optimisation of transport routes, evaluation of control plans, dynamic peak hour evaluation, incident management, traffic emissions, etc.

Models build in AIMSUN2 can be calibrated to a very high degree of accuracy for speeds, car following and flow-density curves. This makes it possible to develop and calibrate models that will represent the actual traffic flows on roads to a high degree of accuracy.

Micro simulation and in particular the AIMSUN2 package can be used to develop a simulation model that represents system behaviour closely enough to allow the model to be used as a substitute for the actual system. This model can then be used to test and evaluate a wide range of changes and options as illustrated with the N4 Platinum Toll Road. Aspects that were tested are interchange layouts, lane configurations, traffic signal settings toll plaza layouts and the combination of payment methods. Micro simulation models proved to be applicable and very useful when congested networks are evaluated. It also assists in conveying the results of investigations to persons not familiar with traffic engineering terminology and concepts.

It was also possible to determine the effect of changes on other parts of the network as well.

References

W. Helly, Simulation of Bottlenecks in Single-Lane Traffic Flow. In: R.C. Herman (Ed.), Theory of Traffic Flow, Proc. Symp. Theory of Traffic Flow, Elsevier, Amsterdam, pp. 207-238, (1961)

J.F. Gabbard, Car-Following Models. In: M. Papageorgiou (Ed.), Concise Encyclopedia of Traffic and Transportation Systems, Pergamon Press, Oxford, (1991).

R. Herman, E. W. Montroll, R. Potts and R.W. Rothery, Traffic Dynamics: Analysis of Stability in Car-following. Operations research, 1(7), pp. 86-106, (1959).

D.A. Wicks, INTRAS-a microscopic freeway corridor simulation model. Overview of simulation in highway transportation, 1, pp.95-107, (1977).

Qi Yang and H.N. Koutsopoulos, A Microscopic Traffic Simulator for Evaluation of Dynamic Traffic Management Systems, Transp. Res. C. Vol.4, No. 3, pp. 113-129, (1996).

R. Wiedemann, Simulation des Verkehrsflusses. Schriftenreihe des Instituts für Verkehrwessen, Heft 8, Universität (TH) Karlsruhe, (1974).

M. Fellendorf, VISSIM: A micrtoscopic simulation tool to evaluate actuated signal control including bus priority, Technical paper, Session 32, 64th ITE Annual Meeting, Dallas, 1994.

P.G. Gipps, A behavioral car-following model for computer simulation. Transp. Res. B, Vol. 15, pp 105-111, (1981).

J. Barceló, J.l. Ferrer, R. grau, M. Florian, I. Chabini and E. Le Saux, A Route Based variant of the AIMSUN2 Microsimulation Model. Proceedings of the 2nd World Congress on Intelligent Transport Systems, Yokohama, 1995.

J. Barceló, J.L. Ferrer, D. García, M. Florian and E. Le Saux, Parallelization of Microscopic Traffic simulation for ATT Systems Analysis. In: P. Marcotte and S. Nguyen (Eds.), Equilibrium and Advanced Transportation Modeling, Kluwer Academic Publishers, 1998.

M. Van Aerde, B. Hellinga, M. Baker and H. Rakha, INTEGRATION: An Overview Traffic Simulation Features, paper presented at the 1996 Transportation Research Board Annual Meeting.

SMARTEST Project Deliverable D3, August 1997, European Commission, 4th Framework Programme, Transport RTD Programme, Contract Nº: RO-97-SC.1059.

TSS-Transport Simulation Systems, December 2000, GETRAM/AIMSUN2 User's Manuals, Version 4.0

D. Manstetten, W. Krautter and T. Schwab, Traffic Simulation Supporting Urban Control System Development, Robert Bosch GmbH, Corporate Research and Development, Information and Systems Technology, P.O. Box 10 60 50, 70049 Stuttgart, Germany, (1998).

T. Bleile, W. Krautter, D. Manstetten and T. Schwab, Traffic Simulation at Robert Bosch GmbH, Proc. Euromotor Seminar Telematic / Vehicle and Environment, Aachen, Germany, Nov. 11-12, (1996)

M. Koka, J. Hourdakis, P. G. Michalopoulos, Computer Aided Testing and Evaluation of Adaptive Ramp Control Strategies, Paper presented at the 79th Annual Meeting of the Transportation Research Board, Washington, January 2000, accepted for publication in the TRB.

O. Balci, Verification, Validation and Testing, in: Handbook of Simulation: Principles, Methodology, Advances, Applications and Practice, Ed. by J. Banks, John Wiley, 1998.

J.P.C: Kleijnen, Theory and Methodology: Verification and Validation of Simulation Models, European Journal of Operational Research, Vol. 82, pp. 145-162, 1995.

THE ADVANTAGES OF MICRO SIMULATION IN TRAFFIC MODELLING WITH REFERENCE TO THE N4 PLATINUM TOLL ROAD

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Mr Venter is a qualified Professional Engineer with a Masters degree in Town & Regional Planning with more than 11 years of experience in transportation planning.

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Experience in micro simulation covers a wide range of models. These models were used for determining the impact of proposes developments, testing geometric design options, traffic signal setting optimisation, the effect of traffic calming measures, toll plaza design as well as incident management.

Major micro simulation models includes a model for the Pretoria-Johannesburg corridor, Marabastad and the N4 Platinum Toll Road.