TSHWANE BRT:
Development of a Traffic Model for the BRT Corridor Phase 1A – Lines 1 and 2

L RETIEF, B LORIO, C CAO* and H VAN DER MERWE**

TECHSO, P O Box 35, Innovation Hub, 0087
*Mouchel Group, 307-317, Euston Road, London, NW1 3AD, UK
**SANRAL Northern Region, Private Bag X17, Lynwood Ridge, 0040

ABSTRACT

The South African National Roads Agency Limited (SANRAL), Implementing Agent of the Tshwane Bus Rapid Transit (BRT) project for the City of Tshwane, appointed Techso in association with Mouchel to develop a traffic model for Phase 1 of the planned BRT Corridor in the City. Phase 1A of the BRT system consists of two lines. Line 1 extends from Mabopane Station to Pretoria Station, and the Line 2 from Pretoria Station to Mamelodi. The project was carried out under a tight deadline, which necessitated an abbreviated approach. This paper presents the process followed to develop the traffic model used to estimate the impact of the BRT infrastructure on private vehicle traffic. This paper addresses the updating of the City's Emme/2 model and extraction of BRT corridors from this network to develop the mesoscopic model in PTV VISUM. From this point the mesoscopic models were calibrated and further microsimulation modelling of critical areas along the BRT corridor were undertaken. The study highlighted the importance of maintaining a City's strategic transportation planning model on an ongoing basis.

1 INTRODUCTION

The South African National Roads Agency, Implementing Agent of the Tshwane Bus Rapid Transit (BRT) project for the City of Tshwane, appointed Techso in association with Mouchel to develop a traffic model for Phase 1A of the planned Bus Rapid Transit (BRT) Corridor in the City of Tshwane. Phase 1 of the BRT system consists of two lines. The first line extends from Mabopane Station to Pretoria Station, and the second line from Pretoria Station to Mamelodi. The purpose of the modelling was to determine the impact that the introduction of the proposed BRT system's infrastructure would have on private vehicle traffic. The project was undertaken under severe time constraints and consequently the study approach had to be adapted accordingly.

2 MODELLING APPROACH

2.1.1 Discussion on Modelling Levels

In order to understand the reason for the use of the various software products that was utilized for this study it is important to appreciate the functionalities and typical applications of the different levels of Modelling.

A strategic demand modelling application (the EMME/2 software in the case of this study) is a tool for developing strategic (or macroscopic) transport models. These types of models are appropriate for modelling large networks because the level of detail of infrastructure is relatively low. For example, the software does not model complex vehicle interaction, but is instead based on a “fluid” analogy and flow-delay curves. The model applies a flow-delay curve to reduce the travel time on a link as the flow increases. Typically this is only applied to links, and not nodes, and therefore intersection delays are not calculated explicitly (although flow-delay curves may be chosen so as to incur additional delay as an approximation of the delays caused by intersections). This means that delays associated with specific turning movements are typically not calculated or taken into account in the model behaviour. While this approach appears simple it allows for large areas to be modelled and is more likely to converge to a final (stable) result. In the same manner these models are useful for modelling regional effects, but can be unreliable at the micro-level, and should therefore be used with caution when, for example, predicting turning movements at intersections.

Mesoscopic modelling (the PTV VISUM software in the case of this study) typically includes all the capabilities of strategic modelling, but also allows for intersections to be analysed using more detailed analysis algorithms. The software utilises the results from such analyses to influence the route choice of vehicles on the network. This type of modelling still aggregates vehicles into a “stream” of vehicles (fluid analogy) and is therefore less computationally intensive than microsimulation models. In this study the well-known Highway Capacity Manual intersection analysis algorithms that are incorporated in PTV VISUM’s Intersection Capacity Analysis (ICA) module was utilised.

Microsimulation modelling (the PTV VISSIM software in the case of this study) works on the basis that every individual vehicle is modelled as an entity and complex vehicle decisions based on interaction with other entities (such as traffic lights, stop signs, other vehicles, etc.) are calculated on a regular (split-second) basis. The large amount of data necessary for coding such a model, as well as the intensity of computation required, makes such models ideal for modelling small networks but uneconomical for modelling large networks.

The terms of reference for this project required the modelling to a mesoscopic level (to allow for intersection capacity calculation). The time constraints however did not allow for the development of a large mesoscopic level network. For this reason a combination of the various models were used. Figure 1 below shows graphically how the level of detail was increased in a stepwise fashion as the model was moved from one software tool to the next. This process is described in more detail in the following sections.

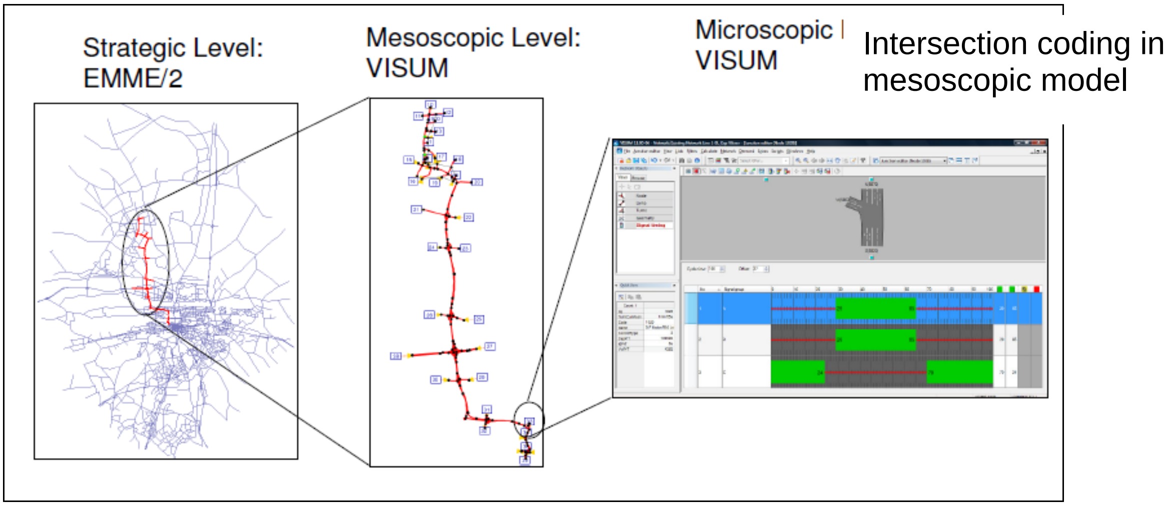

Figure 1: Modelling Levels

3 MODELLING PROCESS

The flowchart in Figure 2 indicates the modelling process followed.

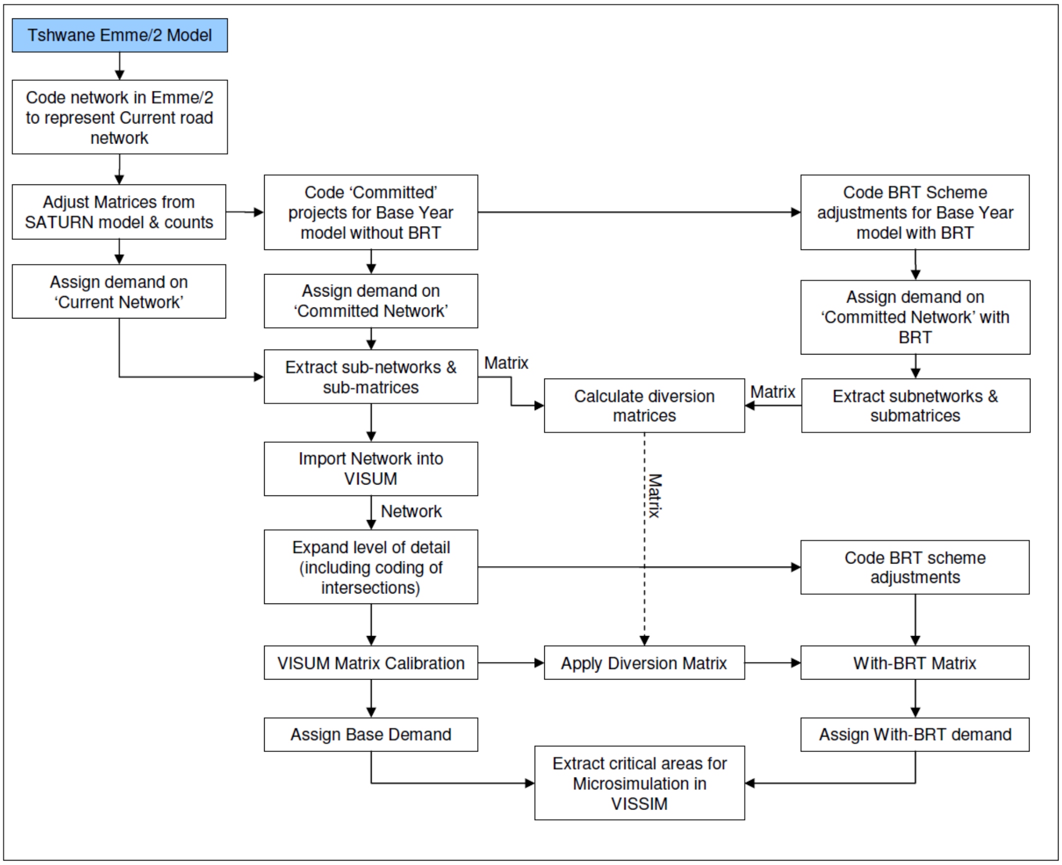

Figure 2: Flowchart indicating modelling process

3.1 Tshwane Strategic Model in EMME/2

The initial proposal for the study was to utilise the EMME/2 model in its current state. With further investigation it was determined that the model was unfortunately dated and additional work was required to update it to include the latest planned and completed network upgrades.

Thirty-seven classified traffic counts were performed at various locations along the BRT corridors during the peak periods. The City of Tshwane also provided 21 unclassified counts along the BRT corridors.

Three road network scenarios were developed in EMME/2 and are discussed below:

3.1.1 Current Road Network

The EMME/2 model did not include all current road network projects. These projects were included in the network to represent the road network as of March 2009. Matrix adjustment was performed within the Current Road Network scenario based on obtained traffic data and a previous SATURN CBD model's zone trip ends. This was undertaken following concerns regarding the accuracy of the Emme/2 model (in terms of trip totals and trip distribution) in the CBD. The extent of matrix adjustments was limited to the BRT corridor (did not include matrix estimation for the whole model). The matrix derived from this process was subsequently assigned to the Committed Road Network Scenarios.

3.1.2 Committed Road Network without BRT

All road network projects currently under construction and committed to be completed by the time that the BRT is in operation (expected 2011) were added to the network to develop the Committed Road Network Scenario. These road network projects are:

- Gauteng Freeway Improvement Project (GFIP) between the Garsfontein Road and N1/N4 interchange
- One-way system in Hatfield
- Improvements along Charles Street
- Road network improvements due to the impact of the GAUTRAIN

3.1.3 Committed Road Network with BRT

This step consisted of including road network changes to accommodate the BRT

3.1.4 Sub-network and sub-matrices

The sub-networks and matrices (of the corridor only) were extracted for each scenario from EMME/2. The expected diversion matrices were calculated by subtracting the corridor sub-matrices of the different scenarios from each other. Figure 3 indicates the calculation of diversion matrices Delta A and Delta B from the Emme/2 sub-matrices.

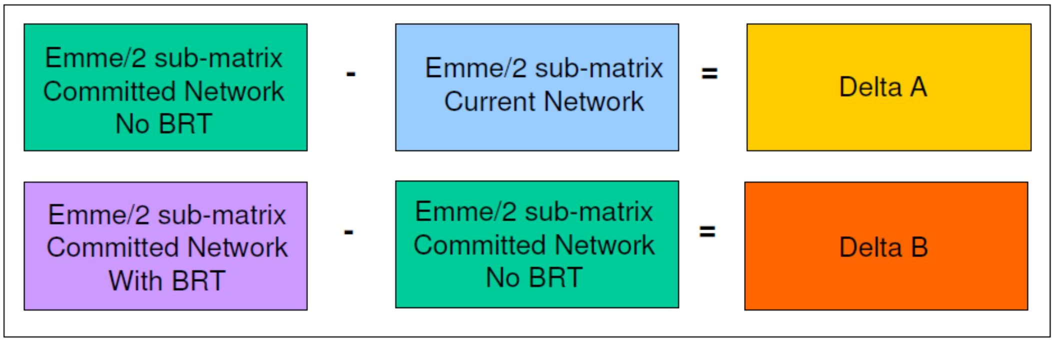

Figure 3: Calculation of matrices Delta A and Delta B

3.2 <u>Mesoscopic Modelling in PTV VISUM</u>

The sub-networks and matrices were then imported into PTV VISUM. This method (whereby the “with-BRT” scenario sub-matrix and sub-network were imported from the EMME/2 model into PTV VISUM) implies therefore that the imported matrices already include the wide-area diversion effects. The approach relies on the EMME/2 model to predict wide area diversion and the modellers had to take account of the fact that wide area diversion results cannot take account of intersection modelling results from the mesoscopic model.

The PTV VISUM model (mesoscopic model) was enhanced by entering additional road network data. This data included:

- Intersection control type
- Signal data for signalised intersections
- Intersection lane configuration

The sub-matrix for the Current Network derived from EMME/2 required further calibration in the mesoscopic model. For this all available traffic count data was entered into the VISUM model and the calibration was run. The resulting fit between modelled and observed data appeared sufficient for the purpose of the model.

The diversion matrices Delta A and B were subsequently added to the calibrated demand matrix to yield a new estimate of the demand for the "without BRT" and "with BRT" mesoscopic models. Figure 4 depicts the calculation of PTV matrices by applying diversion matrices Delta A and Delta B.

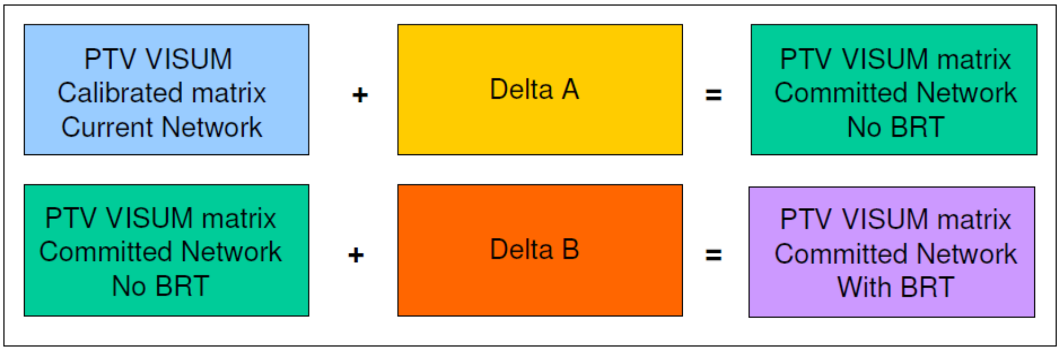

Figure 4: Calculation of PTV Matrices

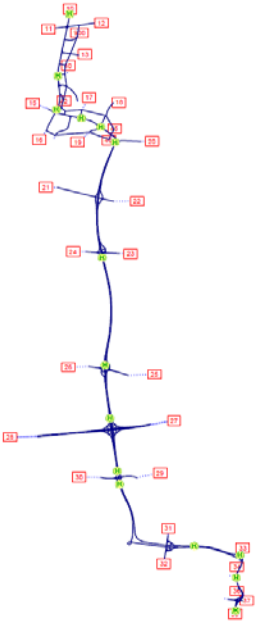

Figure 5: View of the Mesoscopic Model for Line 1 in PTV VISUM

3.2.1 General BRT Principles and Operations

The following principles and operations for lanes were applied to the BRT network scenario:

- Median running on two way roads
- Centre lane on multi-lane one-way roads (not right-hand lane). This is to allow access to developments and side roads on either side of the BRT lane. This however has the implication that private traffic will have to select the appropriate side of the BRT lane upon turning into one-way road.
- No conflicting movements allowed across BRT lane unless movements are separated in time by signals. This implies that all intersections on the BRT route with movements across the BRT lane must be signalised. Some minor non-signalised intersections were changed to left-in, left-out.
- To add an additional lane for BRT as far as practical (to keep the number of lanes for private vehicle unchanged).

The following principles and operations for intersections apply to the BRT:

- Any area where there may be a conflict between BRT and private vehicles must be signalised.

- The BRT should receive as much green time as possible to reduce waiting time at intersections. This is achieved by operating the BRT at the same time as non conflicting movements. Such operation requires all right turns from private vehicle lanes across the BRT lane to be separately signalised, which in turn necessitates such right turns to be protected by a dedicated right turn signal. In light of the above the phasings for current signalised intersections were adjusted as follows:
    - Group BRT with all non-conflicting movements
    - Accommodate all conflicting movements in other phases
    - Maximise green time for BRT to minimise stopping delay at red signals
    - Accommodate right turns in protected phases
    - Minor accesses become left-in, left-out

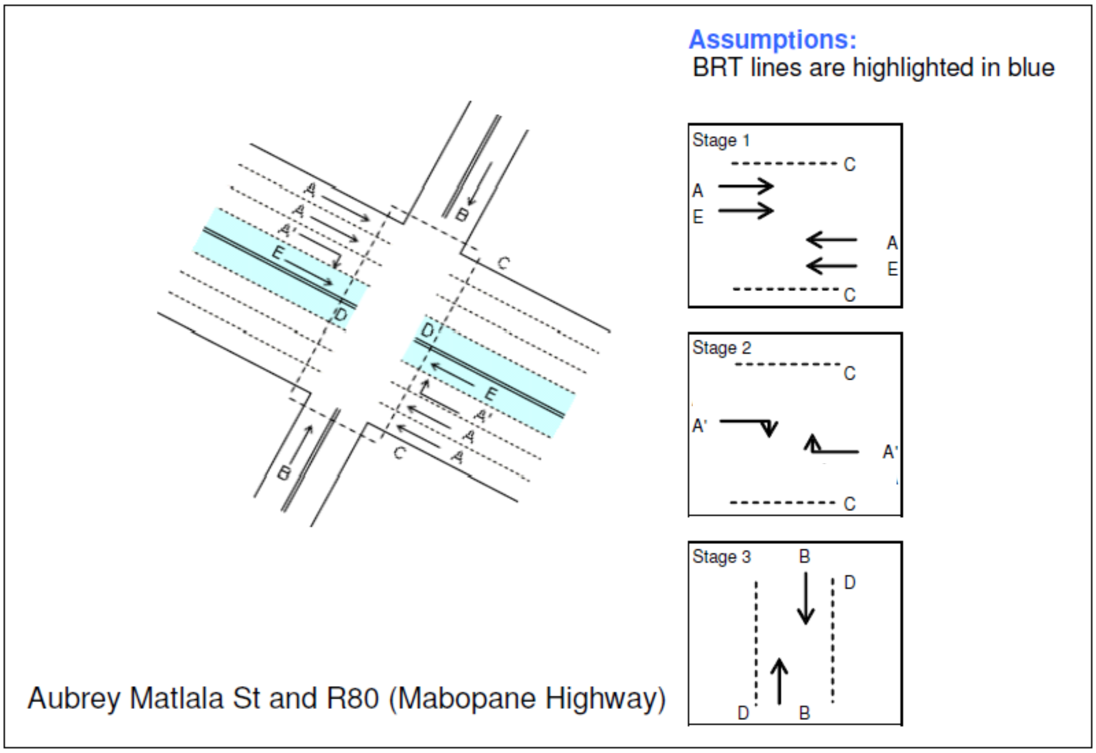

Figure 6: Example of Intersection Phasing on BRT Corridor

3.2.2 Validation

Actual travel time surveys were performed along the proposed BRT routes were compared to the modelled travelled times. The modelling results compared sufficiently well to the observed data and the model was consequently considered “fit-for-purpose”.

It is important to consider that the modelling focussed on comparative analyses between the “with BRT” and “without BRT” scenarios in order to estimate the relative impact that the introduction of the BRT system would have on private traffic.

3.2.3 Results

The BRT report for Tshwane has not been made public yet, and therefore the results could not be published in this paper.

While it is not the purpose of this paper to discuss the results of the modelling, but rather the modelling process, the following bullets provide a broad overview of the results:

- The positive impact of the BRT was most prominent on congested roads with low vehicle occupancy figures and vice versa. This was revealed on the northern portions of the R80 where fast-moving high-occupancy traffic conditions exist. Modelling showed that any delay imposed on the private vehicle stream (even in favour of the BRT) could lead to an increase in overall person travel times and the detail design work must be mindful of this.

- In general, and considering routes in their entirety, the following results were obtained:
    - The advantage of the BRT was more pronounced in congested areas such as the CBD:
    - There is a slight decrease in the weighted average speed for passengers travelling with existing modes when the BRT is introduced.
    - There is a substantial increase in the weighted average speed for BRT travellers compared to private travellers.
    - There is an overall increase in travelling speed for the combination of all travellers.

3.3 Microsimulation Modelling in PTV VISSIM

During the course of the study critical areas along the BRT route were identified for further analysis using microsimulation modelling.

The microsimulation models were prepared by exporting the critical areas from PTV VISUM into PTV VISSIM. The detailed intersection geometry and configuration were adjusted to accommodate the BRT system. During the execution of the microsimulation model runs every individual vehicle is modelled as an entity. Intersection capacity analysis results were extracted to compare before and after BRT scenario results. Video clips in 3-Dimensional format were prepared for presentation purposes.

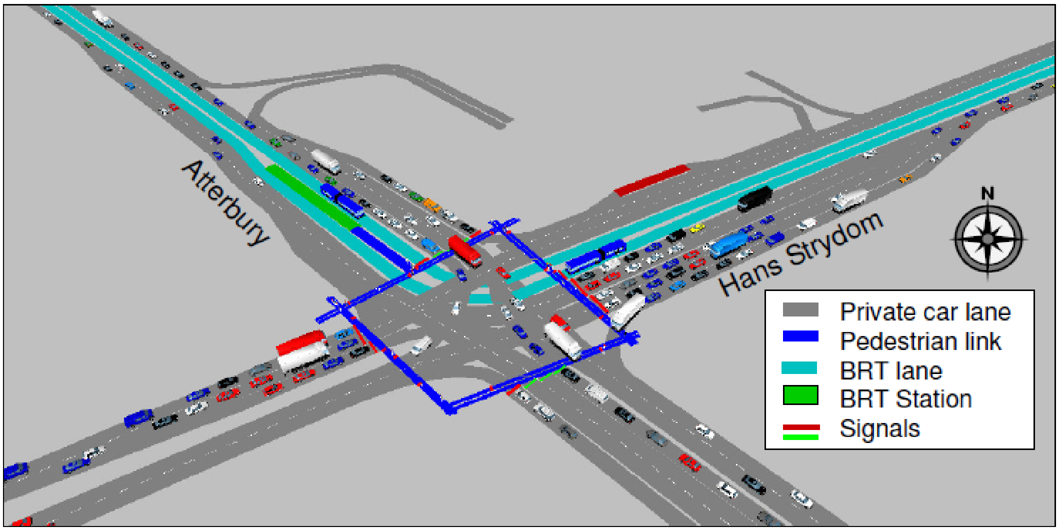

Figure 7: Example of a Microsimulation Model in PTV VISSIM

4 CONCLUSIONS

The following conclusions could be made:

- This project indicated the importance of maintaining a city's strategic model on an on-going basis. New studies often require information output from the strategic models, while the scope and timeline of such studies may not be sufficient to undertake work on the strategic model. It is also important that all work on a city's model be well coordinated and documented so that work undertaken by separate workstreams (conducted in isolation from each other) does not result in irreconcilable outputs.
- The simplified modelling process was shown to yield useful information. It is however important to consider both the advantages and disadvantages of such an approach:
  - The advantages: The method offers a cost and time effective approach by reducing the amount of data and professional time required. Even though the accuracy of the approach can only be determined when real-world "with-BRT" traffic data becomes available, the model results appear sensible and realistic, and validated well (for example in comparison to actual travel time data).

    - The disadvantages: The level of confidence in turning volumes at non-counted intersections is not sufficient for detailed intersection design, and additional traffic-count data may be required for such purposes.
- Understanding the various levels of modelling, and software packages (including the strengths and weaknesses of each) was important for interpreting the results and consequently to deliver useful modelling outcomes.
- The improved integration between, and capabilities of, modern modelling software such as the PTV suite of transport modelling software tools has significantly improved (a) the efficiency of creating models, (b) transferring data between models at different modelling levels and (c) the capabilities and tools available to the modern transport modeller.
- The microsimulation of a transportation system was shown to be a very valuable tool to assist the modelling team, decision makers and politicians alike to:
    - gain a common understanding of operations at specific locations
    - develop detailed operations proposals
    - Support the findings of a higher level analyses
    - Test and/or confirm the feasibility of specific layout options