NORTHERN URBAN DEVELOPMENT CORRIDOR
INTEGRATING LEVEL OF MODELING

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ABSTRACT

The Northern Urban Development Corridor Study address the long term planning for the area consisting of Phoenix, Verulam and Tongaat where the new King Shaka International Airport is situated up to the year 2030 taking into account the provision of engineering services such as transportation, electricity, water supply and sewerage. This paper focuses on the improvement of the existing eThekwini Transport Demand Model and how this model was adjusted to be able to benefit from an integrated macro, meso and micro level modeling.

The existing eThekwini Transport Demand Model (developed in EMME) was improved by making use of the latest count data, household survey data as well as population and employment estimations. The model was also adjusted to be able to address the issues relevant to this particular project. Impact of the proposed development strategy as well as various network proposals were tested with the updated macro model.

Expansion of the macro model was done by refining the network and the zone system for the study area. This forms the basis for converting the macro model to the meso model (developed in AIMSUN) where congestion due to intersections and control could be identified. This creates the opportunity to evaluate and refine final proposed network improvements and provide better input for cost calculations.

The model could be improved, expanded and integrated between different levels of modeling that made it possible to quantify and evaluate the impact of various measures and proposed road improvements.

1 INTRODUCTION

The Northern Urban Development Corridor (NUDC) Study addressed the long term planning for the area consisting of Phoenix, Verulam and Tongaat where the new King Shaka International Airport is situated (Figure 1) up to 2030 taking into account the provision of engineering services such as transportation, electricity, water supply and sewerage.

The eThekwini model was updated in 2000 using the 1996 census information and various other data sources available at that time and used for various studies since. This model was intent to be applied as the basic tool in this study. Evaluation of the model clearly indicated that the model was not suitable for applying it to a sub area of eThekwini, because the accuracy of the model was not acceptable and the model was not designed for the purposes of this study. Therefore the model could not provide answers to the questions that need to be addressed during the course of this project. It also became clear that a multi level modeling approach was much more appropriate than a single level approach.
This paper focuses on the model improvements and how the model was enhanced to be able to address the appropriate questions and provide the output needed and how the integration of different levels of modeling widens the scope of application and thus assist in improving the long term planning.

2 EXISTING MODEL

The existing model is based on the well known 4-step modeling process. Trip generation and attraction is done for three income groups (high, middle and low) and two trip purposes (Home-based Work and Non-Work). Modal split is done in two steps. The first step is a split between private and public based on a relation between car ownership and the proportion of private vehicle transport. The second step is a split between the public transport modes during the public transport assignment. Trip distribution is done for each trip purpose and mode (private and public). The model generates outputs for the morning peak hour only. This model is very basic and thus provides the basic output, which was not sufficient for this study.

3 MODEL IMPROVEMENTS

3.1 Available Data

Available data consists of recent classified traffic counts obtained from the eThekwini traffic count database as well as from SANRAL and various other studies including additional counts done by the Study Team. Other sources of data were the eThekwini Household Travel Survey done in 2008, rail passenger volumes from PRASA as well as updated population and employment numbers.

3.2 Determining Applicable Improvements

The project scope do not allowed building a model from scratch, but the output required by this study and needs of the client necessitate improvements and enhancements to the existing model.
Based on the time and budget available as well as the data it was decided to do the following improvements:

- Private and public network
- Population and Employment numbers
- Trip Generation and Attraction
- Trip Distribution

### 3.3 Private and Public Network

The first step was to correct the scale as well as the node locations and then splitting some links to increase the accuracy of the horizontal alignment of roads represented in the model. These corrections improve the link lengths in the model and made it possible to present model results later in GIS-format and/or on aerial photos when needed.

Further improvements to the network were the adding of road improvements implemented since 2005. Other network improvements consist of centroid connector re-alignment where needed and U-turn corrections. The rail network’s horizontal alignment was improved and the locations of railway stations were corrected as part of the private network corrections.

Corrections to the private network necessitate corrections to the public transport route definitions to ensure that the routes fit onto the improved network. The only public transport route corrections were the addition of the commuter rail service between Tongaat and Duffs Road Station. The extent of the network improvements is displayed in Figure 2.

![Network Corrections](image)

**Figure 2: Network Corrections**

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3.4 Population and Employment

Various sources of population numbers were compared to get an indication of the fluctuation in these numbers. Population numbers of the model for 2005, 2010 and 2020 were compared to the ‘Accessibility Mapping of eThekwini Social Facilities Project’ of 2006 and the eThekwini Metropolitan Area Zonal Forecast Project of 2007. This comparison is shown in Figure 3.

There is a substantial fluctuation in the population numbers for certain zones. The eThekwini Transport Authority provided the latest population numbers from the Study ‘eThekwini Metropolitan Area Zonal Forecast Project of 2007’ on 26 January 2010 which was consecutively used for modeling purposes. The total population for the area covered by the model for 2009 is in line with what is expected compared to existing population numbers in the model for 2005 and 2010. The calculated employment for 2007 is significantly higher than the previous projections. This increased the employment/population ratio from 0.2265 in 2005 to 0.3018 in 2007. A comparison of the population and employment for the study area and adjacent zones indicates that the 2007 population estimate is close to the previous 2010 estimate. The estimated employment is also closer to the previous 2010 value and not the 2005 value.

3.5 Trip Generation and Attraction

Trip generation and attraction was adjusted to make provision for differences between zones and to compensate for changes in the generation and attraction rates. Some zones need significant adjustments, but the average adjustments are 1.164 for trip productions and 1.586 for trip attractions. The original model in general under estimates the number of trips generated and attracted.
### 3.6 Trip Distribution

The modeled Trip Length Distribution (TLD) for zones in the study area were compared to the TLD obtained from the eThekwini Household Travel Data (Figure 4). It is clear from this graph that there are distinct TLD in the study area. Trip distribution in the model was adjusted to cater for the three distinct TLD patterns.

**Figure 4: Trip Distribution Patterns**

It was found that differences occur between the TLD of private and public transport for each of the areas (Phoenix, Verulam and Tongaat) within the study area. The majority of private transport trips in Phoenix are shorter distance giving an average trip travel time of 28.8 minutes. Trip distribution for Verulam is closer to the classic normal distribution curve (which is radical different compared to the distribution pattern of public transport), giving an average travel time of 42.1 minutes (Figure 5). A substantial proportion of trips in Tongaat are shorter than 15 minutes, but the majority of the trips are longer. The average travel time for trips associated with Tongaat is 37.8 minutes.

**Figure 5: Comparison of 2005 modeled TLD and Household Survey TLD**

TLD for public transport users in Phoenix is close to a normal distribution curve giving an average travel time of 90.4 minutes. Verulam has two patterns. The one is for shorter trips and the other for longer trips. A significant proportion of trips are long distance trips resulting in an average travel time of 104.2 minutes. The majority of public transport trips in Tongaat are over a shorter distance, but there are trips over longer distances. The graph clearly shows that the majority of trips are in Tongaat and within the immediate surrounding, giving an average travel time of 70.8 minutes. The distribution is displayed in Figure 6.
3.7 Impact of the Improvements

The model did not compare acceptable to the private vehicle traffic counts and resulted in an $R^2$ of 0.536 which is too low for this kind of study and the spread of the scatter graph is too wide to be able to rely on the results obtained from the model. After the improvements were implemented as mentioned earlier the $R^2$ improved to 0.912, which is acceptable and the spread narrowed significantly (Figure 7).
The modal split model was not adjusted, neither the route characteristics in the model. A comparison of the rail and road based passenger volumes across the Umgeni screen line revealed that the model was biased towards road based public transport. After improving the split between rail and road based public transport the $R^2$ for Rail passenger volumes improved from 0.586 to 0.729.

![Improvement of Rail Passenger Volumes](image)

**Figure 7:** Improvement of Rail Passenger Volumes

### 4 MODEL ENHANCEMENTS

#### 4.1 Macro Model (EMME model)

It became clear that the existing model despite significant improvements could not provide the answers needed for this study and thus need further enhancements. The first set of enhancements was a refinement of the zones and network together with enhancing the horizontal alignment of the roads and streets represented in the network. The second set of enhancements was to build a heavy vehicle matrix and improve the production and attractions of King Shaka International Airport (KSIA) to be able to determine the impact of changes in passenger volumes. The third set of improvements was designed to be able to determine the impact of various interventions:

- No intervention
- Trip reduction due to the adjustment of the system
- Modal shift due to congestion
- Peak Spreading
- Combined effect of peak spreading and modal shift due to congestion
- Shortened travel distances

No intervention is self explanatory while the term “trip reduction due to the adjustment of the system” refers to uncoordinated adjustments to system based on individuals trying to improve their journeys.
A sub model was introduced to be able to determine the effect of congestion on modal split. Stated Preference Data gathered for other models were used to develop a simple logit model to be able to quantify the modal shift due to increased levels of congestion. The coefficients used in the utility function are given in Table 1.

**Table 1: Coefficients of Utility Functions**

<table>
<thead>
<tr>
<th>MODEL</th>
<th>TRAVEL TIME</th>
<th>NUMBER OF BOARDING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public Transport</td>
<td>-0.03</td>
<td>-0.4</td>
</tr>
<tr>
<td>Private Transport</td>
<td>-0.07</td>
<td>Not applicable</td>
</tr>
</tbody>
</table>

Peak spreading happens when people adjust their journey start time due to severe increased congestion and fixed business hours. This behavior was taken into consideration in the model to a certain extend by assuming that the current levels of congestion are the upper acceptable levels. This implies that the future levels of congestion would not get worse than the upper levels of congestion experienced currently. Those vehicles that will increase the levels of congestion more than the current upper level will adjust their travel time and will therefore not be on the network during the current peak hour and thus make their journey outside the current peak hour. The impact of peak spreading was applied only to private vehicle trips because they are not restricted by schedules as in the case of public transport.

A summary of the impacts of these interventions is highlighted in Table 2. This table clearly shows that the impact of these interventions is significant and should be accommodated in models and definitely be taken into account in future planning.

**Table 2: Impact of the various Interventions**

<table>
<thead>
<tr>
<th>MODE</th>
<th>NO INTERVENTION</th>
<th>TRIP REDUCTION</th>
<th>MODAL SPLIT</th>
<th>PEAK SPREAD</th>
<th>MODAL SPLIT &amp; PEAK SPREAD</th>
<th>SHORTEN TRAVEL DISTANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public</td>
<td>Person Trips</td>
<td>64 720</td>
<td>64 720</td>
<td>124 142</td>
<td>64 720</td>
<td>95 070</td>
</tr>
<tr>
<td>Change</td>
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<td>0%</td>
<td>+92%</td>
<td>0%</td>
<td>+47%</td>
<td>-14%</td>
</tr>
<tr>
<td>Private</td>
<td>Person Trips</td>
<td>82 002</td>
<td>79 542</td>
<td>44 682</td>
<td>66 713</td>
<td>51 193</td>
</tr>
<tr>
<td>Change</td>
<td>0%</td>
<td>-3%</td>
<td>-46%</td>
<td>-19%</td>
<td>-38%</td>
<td>-13%</td>
</tr>
</tbody>
</table>

4.2 **Meso model**

The macro model is in EMME while the meso model was developed in AIMSUN. The enhanced EMME model was transferred to AIMSUN by means of the seamless integration option of EMME into AIMSUN and vice versa. Consecutive network improvements are displayed in Figure 9. Public transport routes as well as the volume delay functions were transferred to AIMSUN.
Further network corrections in the meso model include corrections to the number of lanes, climbing lanes and centroid connectors. Adding the lane configuration at intersections, coding the turning movements and adding the control plans were further network improvement in the meso model (Figure 10).

Figure 8: Consecutive Network Improvements for Meso Model

Figure 9: Network Improvements in Meso Model
The EMME matrices was transferred to AIMSUN and prepared for the subarea as well as broken up into 15-minute matrices and assigned. The result was a $R^2$ of 0.925 as depicted in Figure 11.

![Graph](image)

Figure 10: Goodness of fit of Sub Area Meso Model

5 CONCLUSIONS

The existing EMME model could be improved to reflect reality to an acceptable level of accuracy for the purpose of this study due to the availability of recent data. Further enhancements ensure that the model could be applied for the purposes of this study. The resultant model could be used to determine the impact of the following:

- Changes in population and employment
- Changes in future land uses
- Changes in public transport characteristics
- New public transport modes
- New roads and improved roads
- Various interventions such as
  - System adjustments
  - Mode shift due to congestion
  - Peak spreading
  - Combination of mode shift and peak spreading
  - Shortening of travel distances

Introducing a meso model and linking it with the macro model made it possible to provide for the following as well:

- Identify exact location of congested areas or road sections.
- Determine the impact of timing plan improvements.
- Determine the effect of dedicated bus lanes in terms of road space, intersection upgrades, etc.
- Optimise future roads and street improvements.
- Better cost estimation of needed road improvements, because exact improvements are known.