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Training Workshop for Developing successful Public-Private Partnerships (PPPs) for increased transport connectivity in Botswana

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Use of Transport Modelling

Multi Modal Transport Model

- Transportation modelling and simulation as interface in the planning process plays an important role in enabling spatial development. The models developed by transport planning professionals are simplified representations of reality which can be used to explore the consequences of particular policies, strategies and spatial changes.
- The transport models forecast transport demand based on expected spatial development, population and economic growth, which translates in the creation of additional trips on the road network requiring expansion or the provision of infrastructure for a variety of modes. Transport modelling is a strong and helpful tool in the Transport Planner's tool kit that supports decisions making.
- Transportation modelling is a young and developing science that has generally developed as part of the evolution of advancing computer technology and was originally developed to solve highway capacity problems. Many mistakes have been made in the past where inappropriate solutions were implemented – with hind sight. A classic mistake includes where new infrastructure provision is considered purely on the basis of the "predict and provide" approach resulting in infrastructure being implemented completely surplus to requirements and unnecessary. The consequence is an unpractical and unaffordable cost to government.

Use of Transport Modelling

Advantages of using Transport Models

- it estimates likely land use transport interactions more quickly and at lower cost and risk than would be through implementation and monitoring or trial by error;
- It helps planners optimise the balance between land use provision and appropriate transport infrastructure and relevant modes to enable sustained economic growth;
- It defines the appropriate level of infrastructure required to support land use and spatial development;
- It defines the appropriate modes of transport to connect land use;
- It weighs up benefits/dis-benefits of various development scenarios; and
- It informs investment decisions by providing input into financial, economic, environmental and other relevant forms of appraisal.

Use of Transport Modelling

Transport Models and PPP Projects

When designing PPP projects within the transport sector, for example, Toll Roads, the Developer/Concessioner should build Base Year and Future Year Transport Models. The latter should be based on an agreed Design/Future Year (normally the end of the Concession Period) to give a representation of how traffic would be in that year. The revenue from the Toll Road is calculated from the quantum of traffic using the concessioned Toll Road and it is quite critical that the Developer gets the traffic flows right since an overestimation of the level of traffic in the Transport Model on particular road links would bring less revenue. Of late there have been some court cases involving the “fitness for purpose” of some of the Transport Models developed for Concession contracts.

Use of Transport Modelling

Disadvantages of Not using Transport Models: Lack of the use of appropriate Transport Modelling leads to:

- Misguided investment in transportation systems that prioritize high speed mobility over local accessibility (This places all other modes of travel at a disadvantage);
- Urban sprawl;
- Under provision of Non-Motorised Transport Infrastructure;
- Commuter public transport services focused on operating mainly during the morning and afternoon peak hours, with limited inter peak services;
- High travel cost (private and public transport) – mobility and accessibility is expensive and has a high economic and social cost; and
- Rural communities often isolated and inaccessible, contributing to the inability to access opportunities and jobs resulting in perpetuated poverty.
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Use of Transport Modelling

Goals of Multi Modal Transport Model

- Improve accessibility and connectivity of all transport modes.
- To ensure the process of regional integration is supported by a robust analysis of issues and impacts leading to reduced cost of trade.
- Ensure sustainable mobility, Improve safety and security of society and the level of service for all modes.
- Provide socially inclusive transport for all to improve the quality of life for Mauritius and its vast visitors.
- Provide an environmentally sustainable transport system.
- Stimulate competition through utilizing alternative transport modes.
- Provide an enabling environment to encourage private sector investment.

Use of Transport Modelling

Steps in Transport Planning

Before exploring what transport modelling is, it is necessary to understand the broad steps involved in transportation planning as to understand how transportation modelling fits into the overall planning process.

Use of Transport Modelling

Steps in Transport Planning

Problem Definition: What is the key transportation, economic and land use issues and problems facing the community? This step may also involve definition of the size of an area to be studied, determination of the scope of the study and the establishment of a steering committee structure or forum to oversee the planning process

Goals, Objectives and Criteria: A consensus should be developed by elected officials and citizens about the future of the community and its transportation system. Goals are developed for the quality of transportation service, environmental impacts and costs and are typically in conflict. A good planning effort will identify the trade-offs between these factors among alternatives in a clear, concise way to help make decisions.

Data Collection: Data must be compiled about the present status of the transportation system and its use. This could include traffic data, public transport ridership statistics, census information and interviews of households about their travel patterns. Data are also gathered on land use, development trends, environmental factors, and financial resources. This will help in problem definition and in developing methods to forecast future travel patterns. Good data are essential to the planning process. The statement 'garbage in/garbage out' applies in transportation planning. Without good data, the results of the planning process have little real meaning and can lead to wrong project selection and an inappropriate developmental direction for the region

Use of Transport Modelling

Steps in Transport Planning

Forecasting: Data from existing travel is used to make forecasts of future travel using travel demand models. This requires forecasts of future population, land use and economic conditions as well as understanding of how people make travel choices. Forecasting requires large amounts of data and is carried out under many assumptions which is based on benchmarking, sensitivity checks and follow up surveys to identify trends.

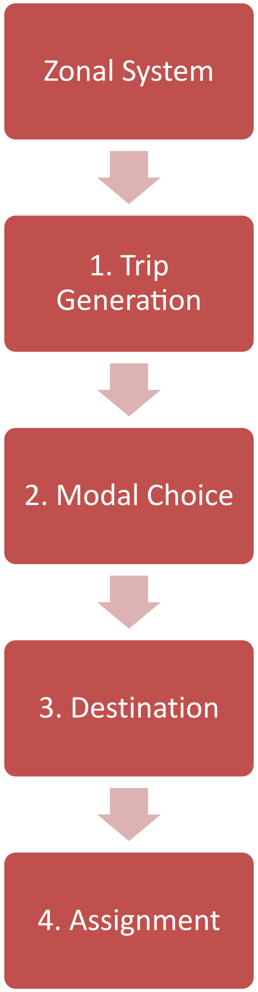
Develop Alternatives: Forecasts are used to determine the performance of alternative future land use and transportation systems. Alternatives normally include different land use and transportation patterns with different mixtures of highway and transit services and facilities. Since land use affects travel and travel affects land use, both must be considered.

Evaluation: Results of forecasts are used to compare the performance of alternatives in meeting goals, objectives and criteria. This information may be extensively discussed by interested citizens, elected officials, different government agencies and the private sector. Ultimately decisions are made by appropriate elected or appointed officials and groups.

Implementation: Once decisions are made, plans should be further developed and refined for implementation. This may include more detailed analysis for design and evaluation following a similar process as above.

Use of Transport Modelling

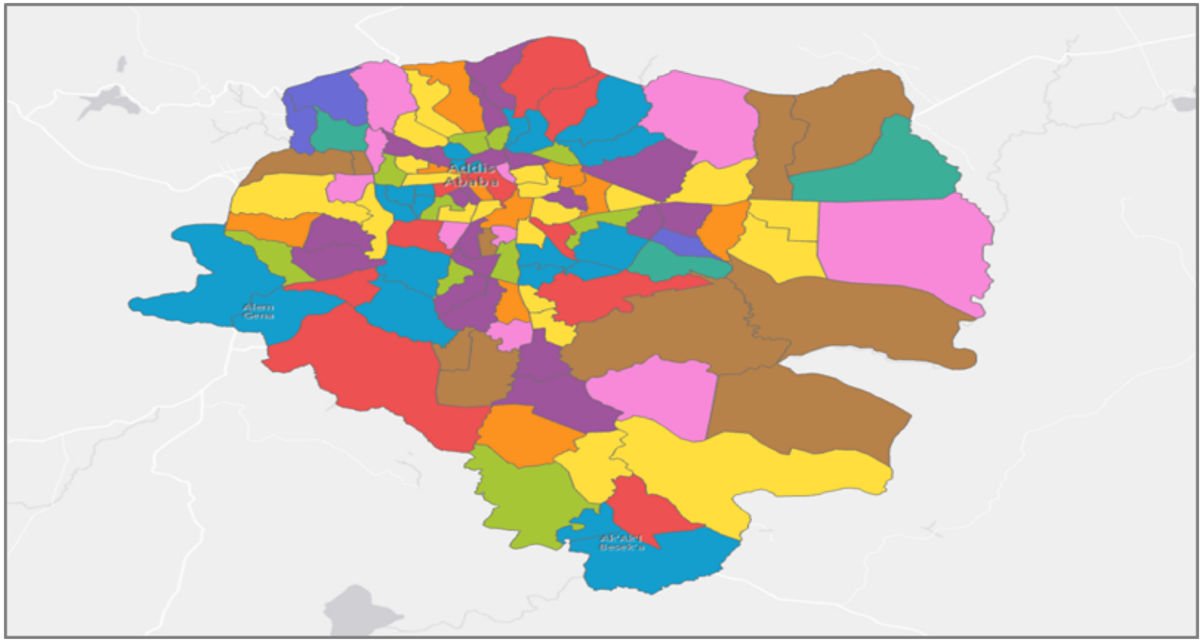
Four Step Model



Use of Transport Modelling

Zonal System: Travel simulation require that an urban area or region be represented as a series of small geographic areas referred to as travel analysis zones. Zones are characterized by their population, employment and other factors and are the places where trip making decisions are made (trip producers) and the trip need is met (trip attractors). Trip making is assumed to begin at the centre of activity in a zone (zone centroid). Trips that are very short, that begin and end in a single zone (intrazonal trips) are usually not directly included in the forecasts. This limits the analysis of pedestrian and bicycle trips in the process. Zones can be as small as a single block but typically are 1/4 to one mile square in area. A planning study can easily use 500–2000 zones. A large number of zones will increase the accuracy of the forecasts but require more data and computer processing time.

Use of Transport Modelling



Example of a Transport Model Zoning System: Addis Ababa

The areas outside the study area which contribute traffic to the study area is defined as external zones. The zones do not just represent areas adjacent to the study area though they represent the "rest of the world".

Use of Transport Modelling

Trip Generation: The first step in travel forecasting is trip generation. In this step information from land use, population and economic forecasts are used to estimate how many trips will be made to and from each zone. This is carried out separately by trip purpose. Some of the trip purposes that could be used are: home based work trips (work trips that begin or end at home), home based shopping trips, home based other trips, school trips, non-home based trips (trips that neither begin or end at home), truck trips and taxi trips. Trips are calculated based on the characteristics of the zones. Trip productions are based on household characteristics such as the number of people in the household and the number of cars available.

Trip Distribution: Trip generation only finds the number of trips that begin or end at a particular zone. The process of trip distribution links the trip ends to form an origin destination pattern. Trip distribution is used to represent the process of destination choice, e.g. "I need to go shopping but where should I go to meet my shopping needs?" Trip distribution leads to a large increase in the amount of data which needs to be dealt with.

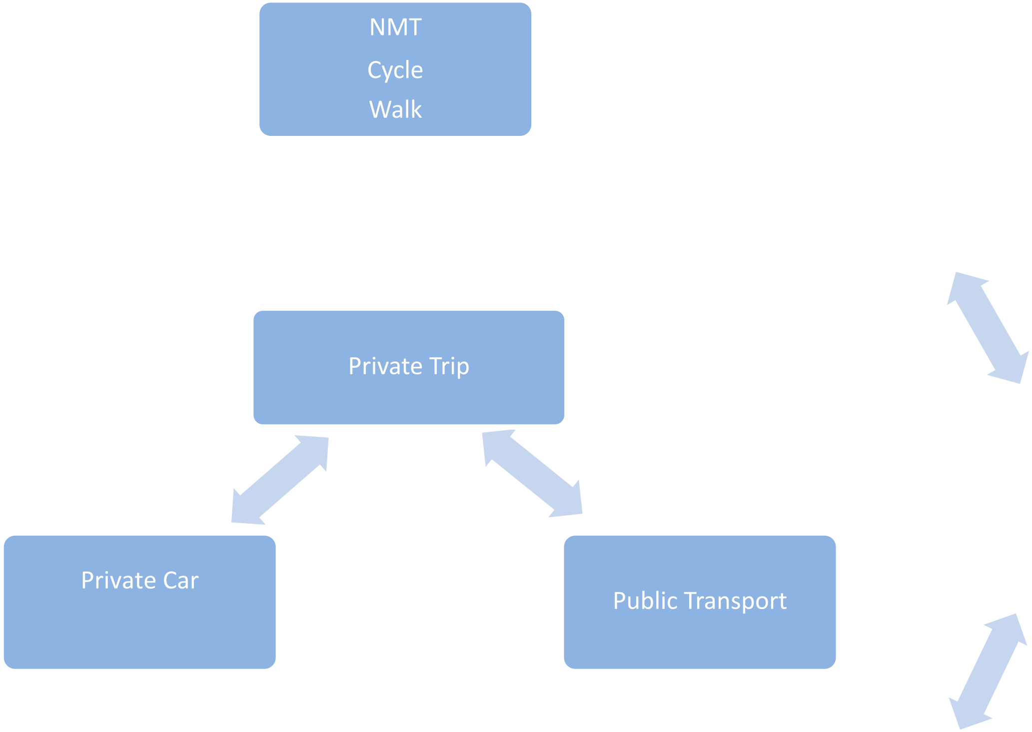
Use of Transport Modelling

Origin–destination tables are very large. For example, a 1200 zone study area would have 1,440,000 possible trip combinations in its O–D table for each trip purpose. The most commonly used procedure for predict trip distribution is gravity modelling. The gravity model takes the trips produced at one zone and distributes to other zones based on the size of the other zones (as measured by their trip attractions) and on the basis of the distance to other zones.

Mode Split/mode choice: one of the most critical parts of the demand modelling process. It is the step where trips between a given origin and destination are split into trips using public transport, trips by car pool or as car passengers and trips by car drivers. All proposals to improve public transport or to change the ease of using the cars are passed through the mode split/car occupancy process as part of their assessment and evaluation.

Use of Transport Modelling

Mode Split:



Use of Transport Modelling

Assignment

- Once trips have been split into highway and public transport trips, the specific path that they use to travel from their origin to their destination must be foun. These trips are then assigned to that path in the step referred to as traffic assignment. Traffic assignment is the most time consuming and data intensive step in the process and is performed differently for highway trips and public transport trips.
- The process first involves the calculation of the shortest path from each origin to all destinations (usually the minimum time path is used). Trips for each O–D pair are then assigned to the links in the minimum path and the trips are added up for each link. The assigned trip volume is then compared to the capacity of the link to see if it is congested. If a link is congested the speed on the link needs to be reduced to result in a larger travel time on that link. When speeds and travel times are changed, the shortest path may change. Hence the whole process must be repeated many times (iterated) until there is an equilibrium between travel demand and travel supply.

Use of Transport Modelling

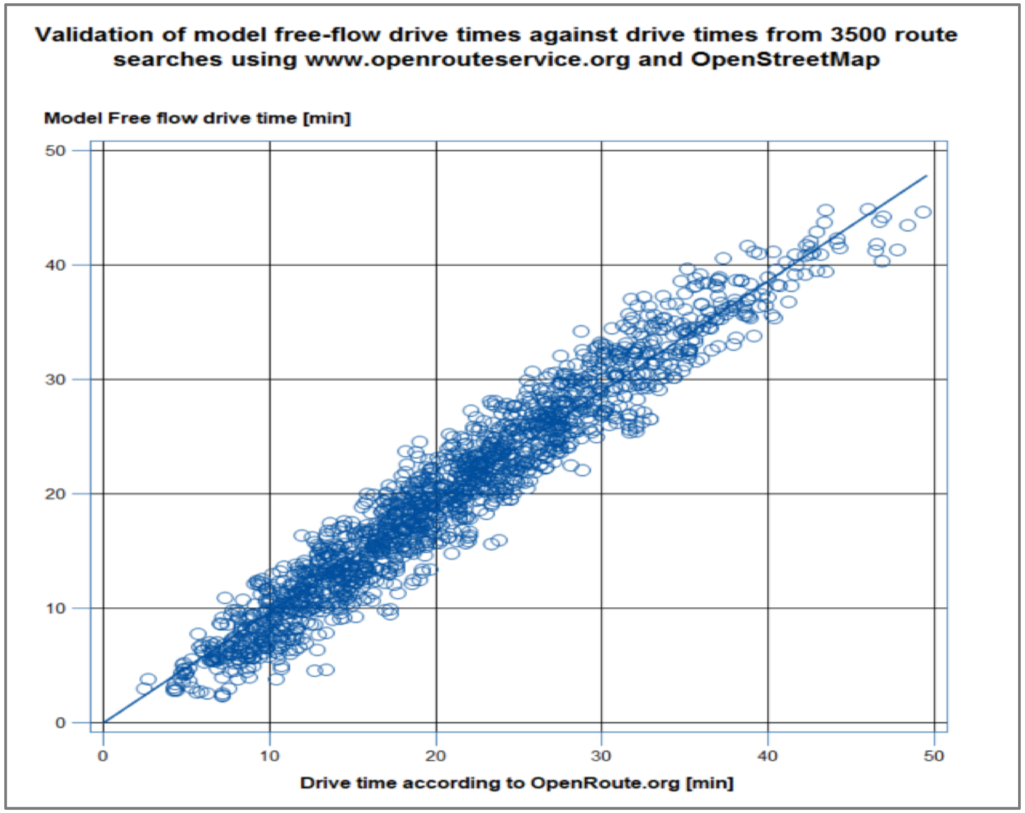
Model Validation and Calibration

Model calibration is the adjustment of constants and other model parameters in estimated or asserted models in an effort to make the models replicate observed data for a base year or otherwise produce more reasonable results;

Model validation is the application of the calibrated models and comparison of the results against observed data; ideally, the observed data are not the same data used for model estimation or calibration.

Model calibration and validation generally occur in an iterative fashion. Model validation may reveal the need to return to the model estimation or model calibration steps. The application of the model using future year conditions requires that the model forecasts are reasonable and consistent with expectations and also might reveal a need to return to the model estimation or calibration step.

Use of Transport Modelling



Validation of model free-flow drive times against drive times from OpenRouteservice.org

Use of Transport Modelling

Main elements of a Transport Model

The main elements of a transport model are as follows:

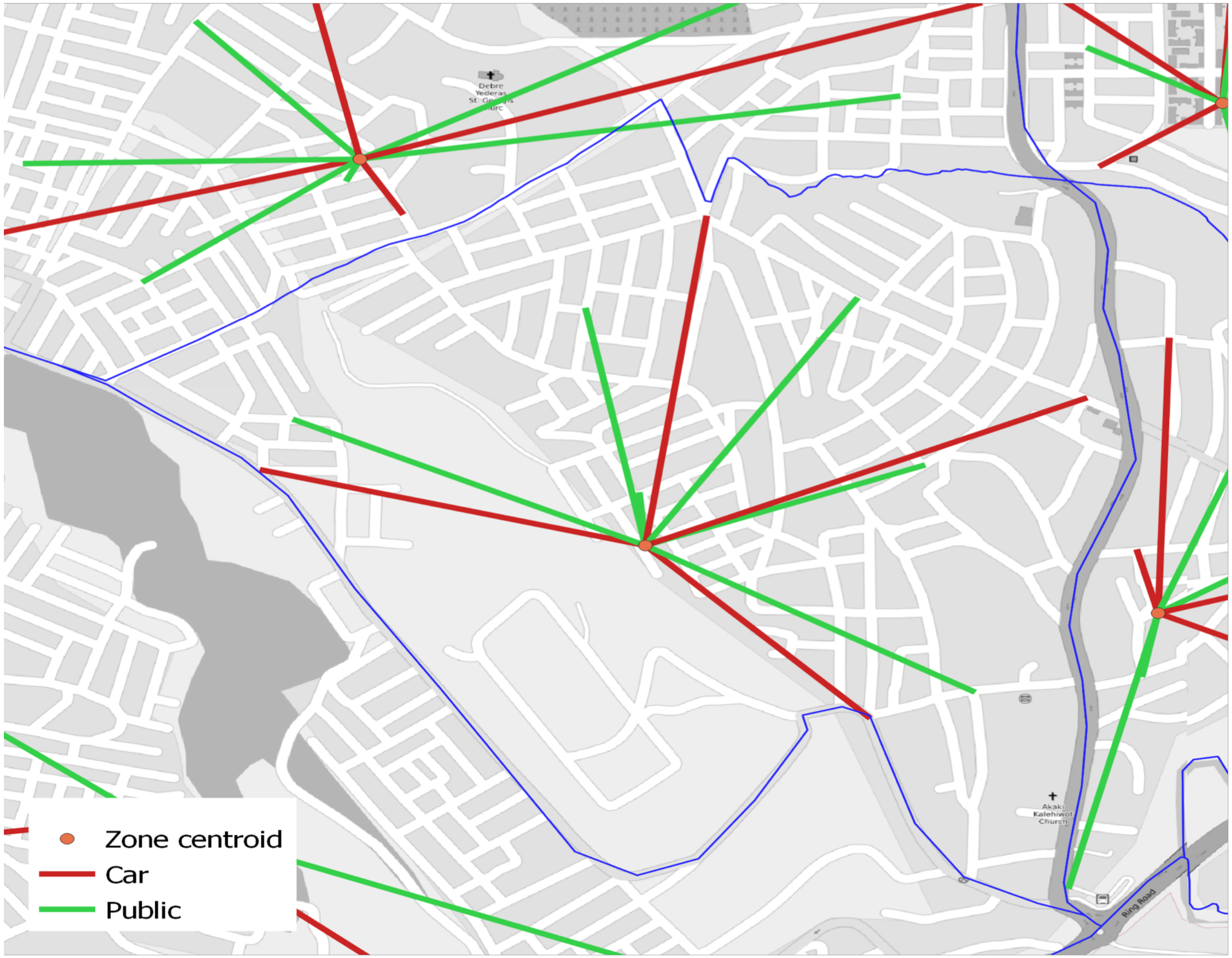
- **nodes** – intersections;
- **links** – segments of the road network;
- **transport zones** – sources and goals of correspondence improvement;
- **connectors** – they connect the centers of transport nodes to the individual and public transport network.

In public transport systems, the above elements are supplemented by public transport stops and lines.

Use of Transport Modelling

Main elements of a Transport Model

Public and Car/Private connectors connecting the network to zone centroid



Use of Transport Modelling

New Data/Traffic Surveys

To develop a Transport Model a set of traffic and socio-economic data is needed:

(a) To assist in the development and calibration of a computerized transport demand model;

(b) To provide up-to-date information so that accurate engineering and planning analysis may proceed;

(c) To document current transport demand among the various transport modes and facilities existing in the area; and

(d) To establish quantitative as well as qualitative interactions among transport, planning, economic, social and environmental sectors.

Use of Transport Modelling

New Data/Traffic Surveys

The surveys typically undertaken are:

Household Interview Surveys (HIS): he HIS is seen as the "backbone" of model development and consists of interviews involving a number of households at an agreed sample size within the study area. Each member of the household is asked a series of questions relating to household characteristics, persons characteristics and trip characteristics. In addition, subsidiary surveys can be conducted with additional, focused questions relating to trip preferences, environmental concerns and opinions on transportation problems, possible solutions and policies.

Roadside Interview Surveys (RSI): The monitoring of trip demand is an important element of the model building process, thus, a series of interrelated and mutually supportive traffic surveys need to be conducted from identified locations over agreed time frames. The questionnaire for this survey will contain questions about the current trip, questions about the respondents and their households such as income, household structure, car availability, and so on. Some basic trip/journey questions would include: where are you coming from (origin address), what were you doing there (origin purpose); where are you going to (destination address), what will you be doing there (destination purpose).

Use of Transport Modelling

New Data/Traffic Surveys

Manual Classified Count Surveys (MCC): This questionnaire will be designed to include all vehicle types (e.g., Motorcycles, Cars, Jeeps & Buses, Luxury Buses, Light trucks; and heavy trucks). Depending on the traffic condition, a survey location may have two or more enumerators counting different type of vehicles. For example, we could have one enumerator counting only cars, and the other counting other vehicles (buses, goods or other vehicles). This means separate forms have to be designed for this purpose.

Automatic Traffic Counts (ATC): This involves counting vehicles automatically at each survey site to enable a full daily profile of traffic to be established. Depending on the resources available the counting can done either manually or using automatic counting equipment. The data will be used to expand the 12 hours traffic to 24 hours and also to account for the variations in traffic across the day. Where resources permit, this survey will be conducted continuously for seven days to also account for variations in traffic across the week.

Personal Interview Survey (PI): This will be similar in content to RSI, except that the respondents will be asked about their reference trip, which is usually the latest trip they have made. It will be conducted at key traffic generators such as schools, hospitals, government departments etc.

Use of Transport Modelling

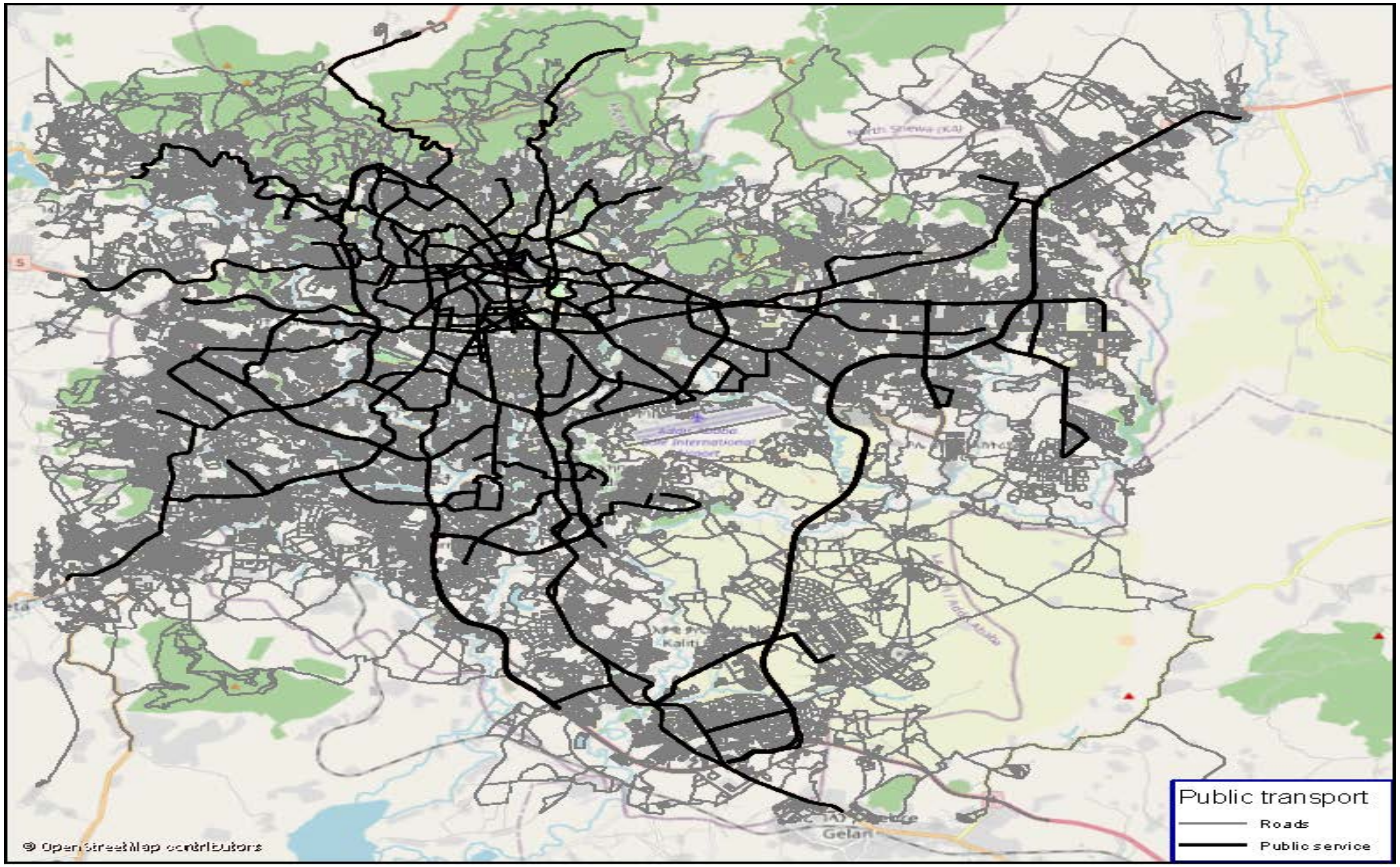
New Data/Traffic Surveys

Road Survey Interviews: Addis Ababa

Use of Transport Modelling

New Data/Traffic Surveys

Public Transport System-Addis Ababa



Use of Transport Modelling

New Data/Traffic Surveys

Freight Vehicle Surveys: The flow of cargo to/from an area, as well as within an area, is of vital importance to any strategy involving commercial vehicles and the facilities used in cargo processing. Thus, in addition to analysis of available data, interviews were conducted which focus on truck owner characteristics, trip patterns as well as opportunities and constraints.

Vehicle Travel Speed Surveys: A series of arterials or main road links can be identified, and vehicle operating speeds determined. These surveys, conducted during varying periods of the day, measure speeds of vehicles operating in mixed traffic.

Road Condition Surveys: The general content of major roads (such as number of lanes, carriageway width, roadside friction, traffic signal control, etc.) can be ascertained via a review of available records, plus focused field investigations.

Use of Transport Modelling

New Data/Traffic Surveys

Transport Network Surveys: As a sister-survey to the road condition survey, the network survey focuses on public transport systems. Results of both the road condition and transport network surveys provide considerable inputs toward the development of road and public transport networks within the framework of the transport model.

Stated Preference Surveys: This survey will be designed to collect all relevant information that do not exist or are difficult to collect using the above survey methods. Some of this information includes user's perception of toll roads, value of time, willingness to pay, and value of different tolling methods (close or open) and so on.

Use of Transport Modelling

Selecting a Transport Model

When selecting a model, the user should begin by defining the requirements of the exercise to be undertaken and the resources required. The requirements that should be defined include:

- What input variables are required, and to what level of detail?
- What output variables are required, at what level of detail and in what form (e.g. on screen results or graphics and results to "come alive" where the movement of cars are observed on screen)?
- Geographical coverage (will a single intersection be simulated, a number of intersections or an entire suburb?);
- Constraints of time and money;
- Is it possible to buy new commercially available software or should new software or processes be developed? and
- Determine whether new data can be collected.

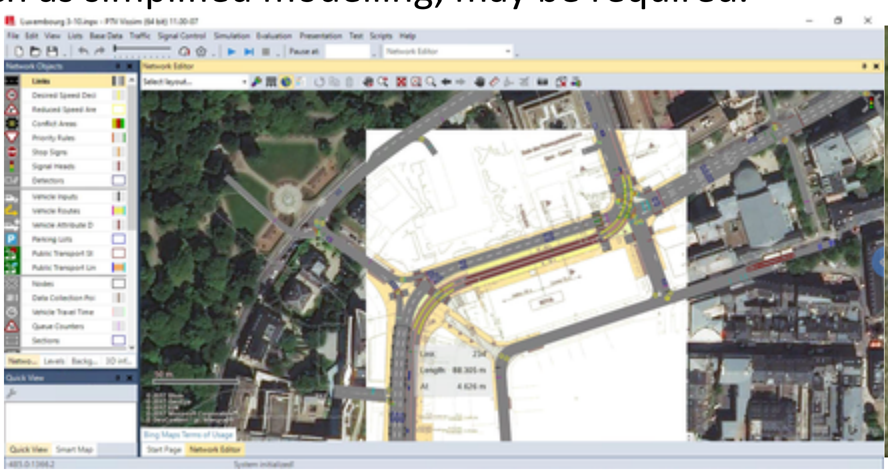
Use of Transport Modelling

Types of Transport Models

Specific types of transport model include:

- Transport models (three or four stage) EMME, TRACKS, VISUM, CUBE, TRANSCAD, TRANSIM;
- Assignment models (single stage) SATURN, CONTRAM, VISSIM, AIMSUN, PARAMICS, SISTM; and
- Operational models (traffic engineering) TRANSYT, SIDRA, LINSIG, OSCADY, ARCADY, PICADY, Operational spreadsheet models.

The main use of 'conventional' transport modelling is in the evaluation of transport network improvement options. However, for some test purposes, especially those involving significant changes to current policies and strategies, transport models are limited and additional techniques, such as simplified modelling, may be required.



Use of Transport Modelling: Case Study

Greater Gaborone Transport Model

Project Objectives

The primary objective of this Assignment is to develop for Ministry of Transport &Communication concrete interventions and a detailed implementation plan for the proposed bus based transport network in Greater Gaborone. In particular the Study proposes a public transport system that will reduce traffic congestion, delays, accidents, increase reliability and hence improve traffic flows.

Study Background

The need for the study was identified by the Greater Gaborone Multi-Modal Transport Study (GGMMTS) which recommended improvements in traffic management; parking; Non-Motorised Transport (NMT) facilities; safety; public transport; inter-modal coordination; urban distribution of freight; international logistics; institutional strengthening; and the creation of a Project Implementation Unit. The Government of Botswana sought to improve the overall management of the transport sector through the Botswana Integrated Transport Project (BITP) that was World Bank funded and, which in turn sought to enhance the integration of transport subsectors with other sectors of the economy and to revamp/modernise the entire transport system.

Use of Transport Modelling: Case Study

Greater Gaborone Transport Model

Study Catchment Area

The area covered by Greater Gaborone is essentially the region within a radius of 80 km around Gaborone City. This area encompasses Lobatse, Kanye, Moshupa, Molepolole and Mochudi, and also includes Tlokweng and Mogoditshane as well as the smaller villages that lie in between.

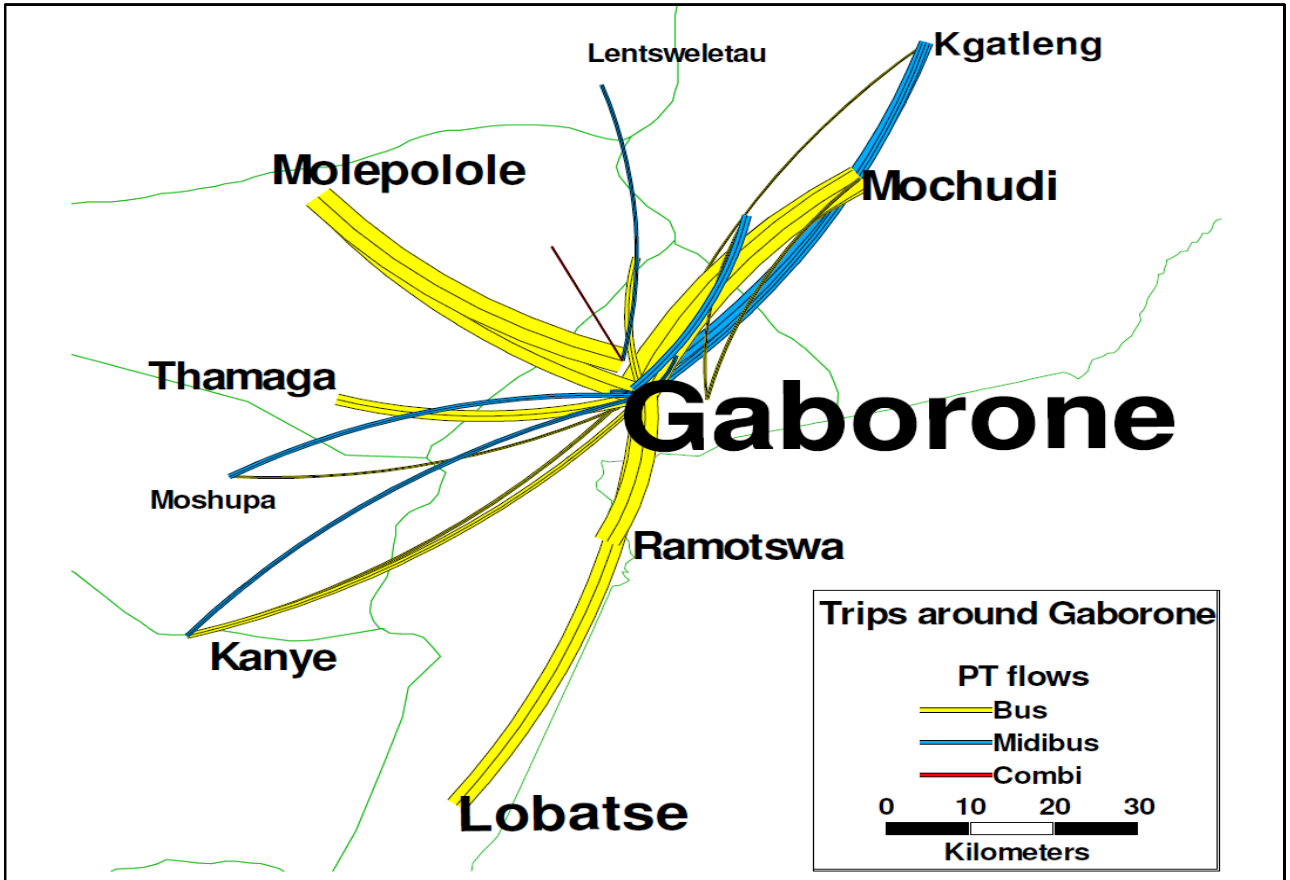
In addition to the three corridors identified by the GGMMTS, two additional corridors linking the city to its suburbs and surrounding towns and villages have been identified. The five radial corridors are:

- the northern corridor which serves small towns and villages along the A1, to the north-west of Gaborone, including those in the Mochudi Planning Area (namely Mochudi, Bokaa, Morwa, Pilane, Rasesa and Malotwane villages), and others such as Oodi, Matebeleng, Mmamashia and areas in between;
- the north-western corridor which serves the built-up areas of Mogoditshane, Metsimotlhabe, Mmopane and Ledumadumane to the immediate west and north-west of Gaborone; and extending all the way to Molepolole;
- the western corridor which serves the southern parts of Mogoditshane, Gabane, Kumakwane and extends all the way to Kanye;
- the southern corridor serving the Kgale Hill area, Mmokolodi and Tloaneng to the immediate

Use of Transport Modelling: Case Study

Greater Gaborone Transport Model

Daily Public Transport Passenger Trips around Gaborone and surrounding towns



Use of Transport Modelling: Case Study

Greater Gaborone Transport Model

Other Study Objectives

Other study objectives include the examination of public transport choices between conventional buses with or without DBLs, BRT, Park and Ride and bus priority schemes, as well as an analysis of the current status of the bus network and recommendation of critical measures for improvement. The study also examines ways of integrating small and medium players in the transport industry and evaluates the risks involved. The critical area of intervention is the Private Sector involvement through PPPs.

Transport Model Development

Traffic Surveys

- A survey of public transport bus and passenger movements was carried out in November-December 2014. The traffic surveys focussed mainly on outward movements from Central Gaborone and Game City to other places; it did not consider inward movements, or passengers boarding midway along a route, as well as external movements, i.e. those movements between places outside central Gaborone. Also there are some routes which were not captured in the survey such as Broadhurst Routes 1 and 2 where combi drivers resisted the surveys that were being conducted.

Use of Transport Modelling: Case Study

Greater Gaborone Transport Model

- Travel patterns and characteristics have been determined from the results of public transport (bus and taxi) surveys, roadside interview surveys (by car) and journey time surveys (by car). Trips by bus are mainly for travel from home to/from work and for education, and to a lesser extent for shopping and personal business.

- Cars are mainly used for travel to/from work and for personal business, and to a lesser extent for shopping and visiting friends and relatives. Taxis are mainly used for work and shopping trips and to a lesser extent for personal business, visiting friends and relatives and for education. As cars are mostly used for work trips, it means they spend most of the day parked at work. This presents a potentially good market for the provision of an attractive bus system together with Park and Ride.

- Almost 60% of people travelling by bus boarded two buses to get to their destinations, whilst forty percent caught one bus. A negligible proportion of bus users took three or four buses to reach their destinations. A large majority of travellers would therefore benefit from through routing and ticketing.

- Eighty percent of all people travelling either by bus, car or taxi, earn up to P20,000 per month; 20% earn more than that. 15% of bus users, 10% of taxi users and 7% of car users earn P2,000 or less.

Use of Transport Modelling: Case Study

Greater Gaborone Transport Model

- In terms of household vehicle ownership among bus, car and taxi users, more than 40% of bus and taxi users come from households with no vehicles owned. However, for car users, almost 50% of them come from households which own one vehicle; only 11% come from households with no vehicles owned, whilst the remainder come from households with 2 or more vehicles.

Person Trips by Mode

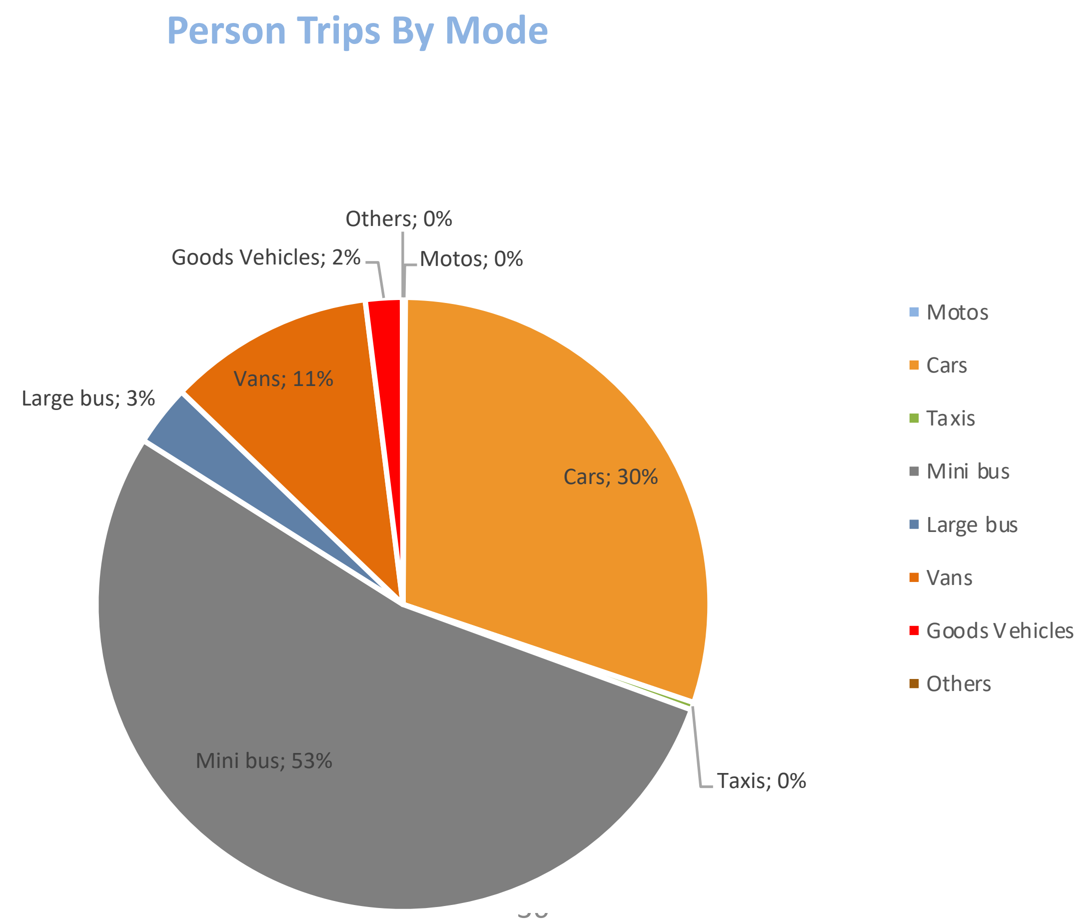
Assumed vehicle occupancies are shown below and these are used to derive the person trips split by vehicle type from the manual classified counts:

Assumed Occupancy Rates for Various Modes

Motorbikes	1
Taxis	1
Car	1.2
Goods	1
Minibus	16
Large Bus	20

Use of Transport Modelling: Case Study

Greater Gaborone Transport Model



Use of Transport Modelling: Case Study

Greater Gaborone Transport Model

The chart above shows that the minibus carries more than half (53%) of the passengers encountered on the roads, whilst larger buses carry 3% of the passengers, assuming the occupancy factors given above. Although minibuses constitute a small proportion of traffic on the roads (8%) they contribute substantially to the movement of people in and around Gaborone.

Use of Transport Modelling: Case Study

Greater Gaborone Transport Model: Forecast Model

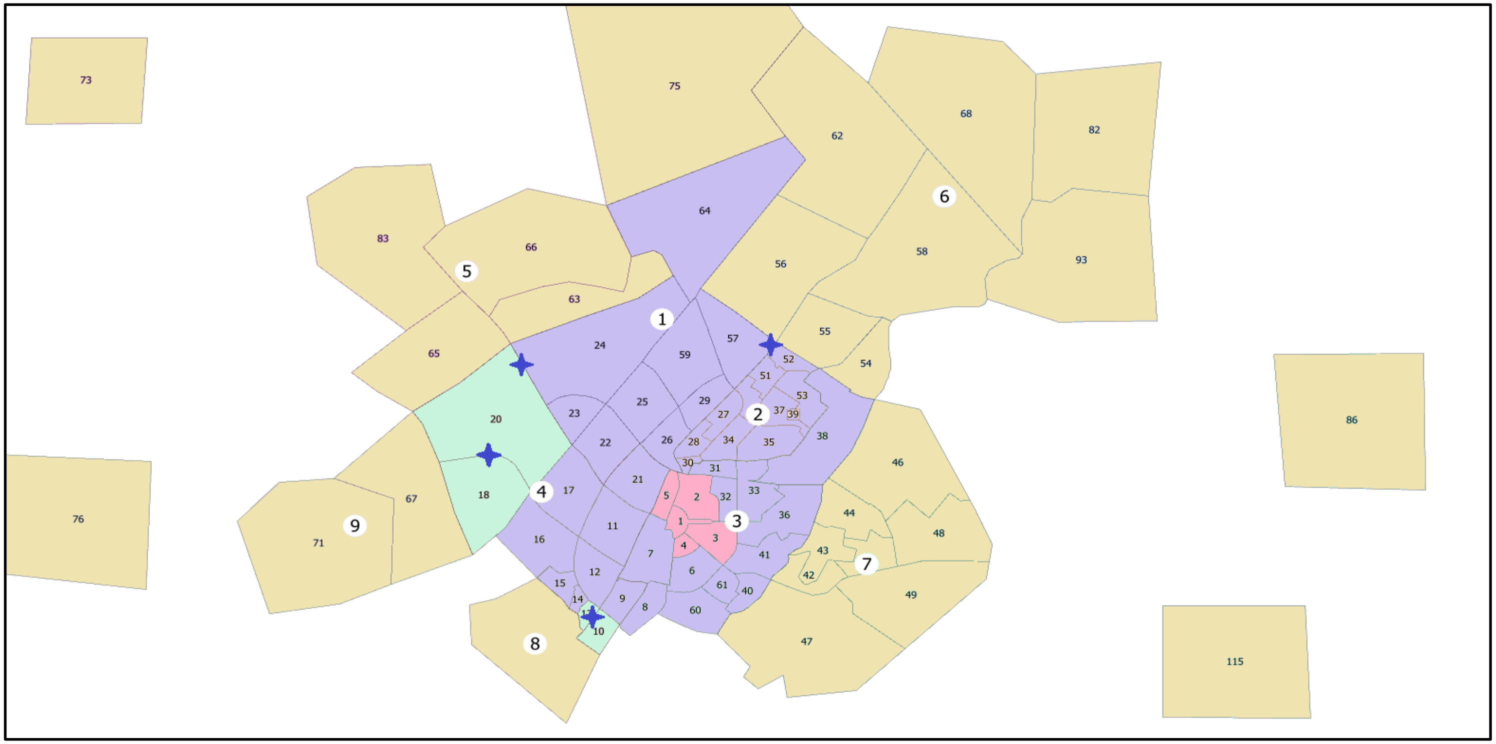
The Transport Demand Forecast Model

- Origin-destination (O-D) bus surveys were undertaken in November 2014 and were used to develop trip matrices to model public transport patronage on the existing combi routes within Gaborone and the long distance routes. A TransCAD transport model of Gaborone which had been developed prior to the current study, was interrogated but could not be run. However, the TransCAD network was transferred to a Visual-tm modelling platform for the current study. The Visual-tm modelling platform was developed by Peter Davidson Consultancy of the UK who were sub consultants to this project and provided all the transport modelling work.
- Bus routes that have been proposed in this study, were coded into the Visual-tm model to replace the current services and the current demand matrix was assigned to the network. The proposed bus service consists of a set of Frequent Core routes and Frequent Local routes to absorb a significant proportion of the total travel demand, plus "Coverage" routes to fill in the gaps.

Use of Transport Modelling: Case Study

Greater Gaborone Transport Model: Forecast Model

The figure below shows the Zoning system that was developed as part of the Transport Model



Notes:

The blue stars indicate tentative sites for Park and Ride carparks.

Zones are represented by small numbers; sectors are represented by large numbers

Zones have been coloured as follows:

Pink : car drivers cannot use PnR, parking charges apply;

Purple : car drivers cannot use PnR;

Brown : car users can use PnR if travelling to pink zones;

Green : additional zones where car users can use PnR if travelling to pink zones

Use of Transport Modelling: Case Study

Greater Gaborone Transport Model: Forecast Model

- A model of the existing minibus routes was developed, onto which the proposed bus routes were superimposed as shown in the above map. It was then run to reproduce bus flows to match existing minibus passenger flows, together with potential Park and Ride passengers. The figures for Park and Ride are a result of the availability and attractiveness of a faster high quality bus service as well as the Park and Ride facility.

Park and Ride Forecasts with Parking Charges in the City Centre

The transport model was run taking into account parking restraint in the city centre, the restraint being in the form of parking charges. Sensitivity tests were undertaken for various levels of parking charges and for different Mode Perception Penalty (MPP) values (in minutes). A third variable that was used was catchment area. Three scenarios were considered:

- Scenario 1: only travellers from sectors 5 to 9 would consider to either use Park and Ride or not;
- Scenario 2: travellers from sectors 5 to 9 plus those from zones 10, 13, 18 and 20 would consider using Park and Ride;
- Scenario 3: all travellers with a destination in the city could consider using Park and Ride.

Use of Transport Modelling: Case Study

Greater Gaborone Transport Model: PnR Forecast Model

Model results for Park and Ride with parking charges at different levels of MPP and catchment areas were obtained. Results showed that as MPP increases the number of car drivers opting to use Park and Ride decreases. However, for each MPP value, as the parking charge in the city centre increases, the number of car drivers opting to use the Park and Ride also increases. Also, with an increase in the size of the catchment area, the number of potential Park and Ride users increases.

This case study has only given the public transport element of the model. There is a Network Traffic Model that forms part of this Transport Model as well.