EXECUTIVE SUMMARY

INTRODUCTION

The City of Lagos is currently one of the 20 largest cities in the world with an estimated population of more than 10 million people. The Population Division of the United Nations is predicting that Lagos will grow to 17 million by 2015, which will make it the 9th largest city in the world.

One of the disadvantages of fast growing populations is the inability of infrastructure development, especially road infrastructure, to keep up with the pace of development. Lagos is no different in this respect. The Government for the State of Lagos has not been able to provide the required funding for investment in infrastructure (capital formation) as is required by the fast growing economy of this urban centre. The result is traffic congestion and long travel times at a scale only found in a large metropolis. There is no doubt that this situation impacts negatively on future growth and the natural and social environment.

The Government for the State of Lagos has consequently embarked on a "*road*" to solicit proposals for private sector involvement in the development of road infrastructure through concessioning. The "Lagos Infrastructure Projects" was initiated by ARM in response to the invitation by the Government.

Four projects were "awarded" to ARM for potential concessioning. These projects were investigated and analysed during a Pre-Feasibility Study by the AFRICON-BKS JV, which was completed in June 2004:

- Project 1: Opebi-Mende Link Road;
- Project 2A: Osborne Link;
- Project 2B: Southern Bypass;
- Project 3: 4th Mainland Bridge;
- Project 4: Coastal Road

These projects can potentially change the spatial distribution of land use activities in Lagos by providing a ring-road system to connect the Mainland with the Lekki Corridor via Ikorudu but also by providing additional capacity to transverse the Islands.

The Pre-Feasibility Study has prioritised these projects in terms of their short-term viability and ability to be financed solely by the private sector.

Three of these projects were identified as the highest priorities to be investigated in further detail. This Feasibility Study consequently included the following three projects:

- ⇨ The Opebi-Mende Link Road, a 3.680 km access link on the Mainland;
- ⇨ The Lekki Corridor, the improvement of the Epe Expressway and the construction of a new parallel facility in this corridor, namely the Coastal Freeway, both approximately 50 km in length (it also includes the construction of 10 interconnecting road links); and
- ⇨ The Southern Bypass, a 3.375 km new freeway on the alignment of Ahmadu Bello Way on the western and southern shores of Victoria Island.

The terms of reference for the Feasibility Study has also included the execution of Environmental Impact Assessments for these projects. The results of these studies are however reported separately.

This Feasibility Study consists of three primary elements, which are critical components of any Feasibility Study, namely:

- ⇨ Traffic demand simulation studies to determine the toll eligible traffic and the toll traffic at different toll rates;
- ⇨ Conceptual design of infrastructure projects and the cost estimation on a life-cycle basis, i.e. including road and bridge capital and maintenance cost, as well as toll operating and maintenance cost throughout the life of the concession;
- ⇨ Financial viability analyses to determine cash flow streams for revenue and costs, and the expected internal rate of return on equity invested in the project.

VALUE OF TIME (VOT)

Another aspect, which was dealt with comprehensively is the willingness-to-pay toll fees and their affordability. This information was obtained through personal interviews and by means of stated preference (SP) surveys (revealed preference surveys could not be used since similar examples of tolling does not exist currently). Average hourly income levels were also obtained as another indication of the value of time (VOT).

Although the LOGIT Models (highly significant coefficients) have suggested an average VOT of 100 Naira per hour, other evidence have suggested a significantly higher value.

A value of time of 100 Naira per hour was eventually adopted as a conservative (pessimistic) estimate and 200 Naira per hour as a realistic estimate.

METHODOLOGY

In order to achieve the goal, the study was structured according to the following tasks:

- ⇨ Describing the network
- ⇨ Investigating land use planning and future growth in the study area
- ⇨ Conducting traffic surveys
- ⇨ Identifying existing traffic characteristics
- ⇨ Conducting and analysing stated preference surveys
- ⇨ Design a toll strategy
- ⇨ Traffic modelling
- ⇨ Modelling of road user benefits
- ⇨ Determining expected future traffic
- ⇨ Performing capacity and operational analysis

RESULTS OF VIABILITY STUDY

The results of the viability study are hence discussed separately for the three projects.

Opebi-Mende Link Road

The following is concluded:

1. The required capital cost for this project is USD 96.1 million for the initial construction of 3.680 km of 4-lane freeway including two partial systems interchanges, one mainline toll plaza, and two ramp toll plazas.

2. The demand simulation for the Opebi-Mende Link Road was based on generally accepted transportation planning methodology and techniques, which have included the calibration of the model with extensive field data.

3. The result of these transportation-planning studies, i.e. the expected demand, was verified based on the expected benefits in terms of reduced travel times (higher average speeds), and savings in fuel cost.

4. A value of time (VOT) of 200 Naira per hour is applicable. See the discussion in Section 2.

5. The required toll tariff for Class I vehicles for a real ROE of 16% is 159 Naira per trip for the realistic scenario. The toll tariff for the optimistic scenario is 140 Naira per hour. An increase of 10% and 20% in the estimated costs will result in toll tariffs of 172 Naira and 186 Naira respectively.

6. The required toll tariffs (realistic scenario) translate to high unit rates (per km) based on the short distance of 3.680 km, i.e. 31 US cents per km. This compares to an average SA rate of 5 US cents per km for Class I vehicles.

7. Commuters will have to pay for two trips per day, which translates to 318 Naira per day, and ±7,000 Naira per month (22 days).

8. The surrounding road network is generally congested. The proposed toll link will therefore only provide an improvement in travel conditions for a very short distance of the total trip lengths. The transportation model has furthermore shown that it is difficult to obtain access to the new link (due to congestion on the links that connects to the new link) and some benefits are lost when traffic has to divert to use this new linkage.

9. Several alternatives routes are available and are currently being used by the traffic in the area. It would thus be very easy to avoid the new road link – i.e. potential low attraction.

10. Assuming a value of time of 200 Naira per hour, translates to a required average time saving of 48 minutes (159/200 X 60 minutes) in order to justify the tariff based on the cost of travel time alone. Since the average trip times in this area is in the order of one hour (average of 54 minutes from SP surveys), the required savings is impossible to obtain.

11. It is thus concluded that the construction of the Opebi-Mende Link as a concession is a risky undertaking with relatively high toll tariffs and a high risk of diversion. This project is not viable, as a stand-alone project and will require a subsidy.

Lekki Corridor

The following is concluded:

1. The required capital cost for this project is USD 156.3 million for the initial construction of the following:
   - ⇨ New construction of 6.5km 4-lane freeway;

- ⇨ New construction of 13.5km two-lane rural highway;
- ⇨ New construction of 1.7km 4-lane connector roads;
- ⇨ New construction of 7.65km 2-lane connector roads;
- ⇨ Upgrading of 20km 4-lane road to six-lanes including the provision of pedestrian bridges, public transport facilities and street lighting;
- ⇨ Rehabilitation of 27.5 km 4-lane road; and
- ⇨ Construction of four mainline toll plazas.

2. The demand simulation for the Lekki Corridor was based on generally accepted transportation planning methodology and techniques, which have included the calibration of the model with extensive field data.

3. The result of these transportation-planning studies, i.e. the expected demand, was verified based on the expected benefits in terms of reduced travel times (higher average speeds), and savings in fuel cost.

4. The construction of the High Future Capex option for the Lekki Corridor is recommended; i.e. this includes the upgrading of the section of the Coastal Freeway between the 4th Mainland Bridge and Eleko Beach to a four-lane freeway in year 20 of the concession.

5. Toll Tariffs in the range of 100 N to 110 N will result in a real ROE of 16% pa, which translates to average toll rates of approximately 6 US cent per km for Class I vehicles (This compares to an average SA rate of 5 US cents per km for Class I vehicles.)

6. The weighted average utilization of the number of toll plazas in the corridor is about 2.0 per motorist.

7. The risks of this project is low:

   - ⇨ Both the existing Epe Expressway and the new Coastal Freeway will be tolled;
   - ⇨ Opportunities for diversion is low given that the supporting road network is poorly developed and consists mainly of local streets through township developments – it can thus be expected that only short distance local trips will avoid the toll plazas;

- ⇨ The Lekki Corridor is an established high growth area that supports commercial, business, and medium-to-high income residential development;

- ⇨ The development and implementation of improvements in the Lekki Corridor can be phased as is shown in the table that follows – it is thus possible to delay the implementation of future upgrading if the actual traffic growth is lower than the forecasts;

8. The implementation of the concession will result in substantial benefits as is shown in this report. Without the implementation of this concession, the future growth in this corridor will slow down dramatically and development will be constrained by the limited road capacity.

9. It is hence concluded that this project is viable as a toll concession at affordable toll rates with the recommended improvements shown in the following table.

Table 6-42: Recommended Improvement during Concession Period – High Capex Scenario

Period from start of concession			10 Years	15 Years	20 Years	30 Years
Year end			2016	2021	2026	2036
Epe Express-way	Falomo to Lekki	1	6-lane Urban Arterial			
	Lekki to 4th Mainland	2	6-lane Urban Arterial			
	4th Mainland to Eleko Beach	3	4-lane Rural Arterial	4 Rural Arterial (Upgrade)		
Coastal Freeway	Akin Adesola to Lekki	1	4-lane Freeway		6-lane Freeway	
	Lekki to 4th Mainland	2	2-lane Rural Highway	4-lane Freeway		
	4th Mainland to Eleko Beach	3	None	2-lane Rural Highway		4-lane Freeway
Links	Admiralty + Lekki	1	4-lane Urban Arterial			
	Gbari + Chevron + 4th Mainland	2	2-lane Urban Arterial	4-lane Urban Arterial		
	Sangotedo + 3x New Town + Eleko Beach	3	None	2-lane Urban Arterial		4-lane Urban Arterial

Lekki Corridor with Southern Bypass

The following is concluded:

1. The required capital cost for the Southern Bypass is USD 129.6 million for the initial construction of the following:
   - ⇨ New construction of 3.375km 4-lane freeway;
   - ⇨ New construction of 3.375km 4-lane frontage roads;
   - ⇨ New construction of 0.8km directionals;
   - ⇨ Construction of three underpasses and two interchanges; and
   - ⇨ Construction of two ramp plazas.
2. The demand simulation for the Lekki Corridor with the Southern Bypass was based on generally accepted transportation planning methodology and techniques, which have included the calibration of the model with extensive field data.
3. The result of these transportation-planning studies, i.e. the expected demand, was verified based on the expected benefits in terms of reduced travel times (higher average speeds), and savings in fuel cost.
4. Toll Tariffs in the range of 130 N to 140 N – in the Lekki Corridor which includes the Southern Bypass - will result in a real ROE of 16% pa, which translates to average toll rates of approximately 8 US cent per km for Class I vehicles (This compares to an average SA rate of 5 US cents per km for Class I vehicles.)
5. The implementation of the Southern Bypass will contribute significantly to reduce congestion on the Lagos Island, Ikoyi, and the Victoria Island:
   - ⇨ Traffic movements between the Mainland, Lagos Island/Ikoyi, and Victoria Island can currently use only one of two bridges to cross the Five Cowrie Creek, namely Ahmadu Bello Way Bridge and Falomo Bridge (Kingsway Road);
   - ⇨ Both routes, Ahmadu Bello Way and Kingsway Road (Falomo Bridge), are heavily congested during peak periods;
   - ⇨ The construction of the proposed Southern Bypass on the alignment of Ahmadu Bello Way will provide additional north-south capacity transversing Lagos Island/Ikoyi and crossing the Five Cowrie Creek;

⇨ The construction of the directionals between the eastern Ring Road and the new Southern Bypass will enable the optimum utilization of a facility which is currently under utilized, i.e. the eastern section of the Ring Road;

⇨ The construction of the Southern Bypass will assist to distribute more traffic to the new Coastal Freeway over the most western section of the Coastal Freeway, which will relieve congestion on Maroko Road and Akin Adesola Road.

6. The implementation of this project will result in substantial benefits in terms of the Mainland-Victoria Island/Ikoyi-Victoria Island linkage and the optimum utilization of the new Coastal Freeway. Without the implementation of this project, the full benefits of the Lekki Corridor cannot be realized.

7. It is hence concluded that this project is viable as a toll concession and should be pursued as a logical extension of the implementation of the Lekki Corridor.

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1 PRE-FEASIBILITY STUDY AND SCOPE

The City of Lagos is currently one of the 20 largest cities in the world with an estimated population of more than 10 million people. The Population Division of the United Nations is predicting that Lagos will grow to 17 million by 2015, which will make it the 9th largest city in the world.

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Four projects were "awarded" to ARM for potential concessioning. These projects were investigated and analysed during a Pre-Feasibility Study by the AFRICON-BKS JV, which was completed in June 2004. Figure 1-1 shows the relative location and relationship between these four projects:

- ⇨ Project 1: Opebi-Mende Link Road;
- ⇨ Project 2A: Osborne Link;
- ⇨ Project 2B: Southern Bypass;
- ⇨ Project 3: 4th Mainland Bridge;
- ⇨ Project 4: Coastal Road

It is clear from the keyplan that these projects can potentially change the spatial distribution of land use activities in Lagos by providing a ring-road system to connect the Mainland with the Lekki Corridor via Ikorudu but also by providing additional capacity to transverse the Islands.

The Pre-Feasibility Study has prioritised these projects in terms of their short-term viability and ability to be financed solely by the private sector.

Figure 1-1: Key Plan

Three of these projects were identified as the highest priorities to be investigated in further detail. This Feasibility Study consequently included the following three projects:

- ⇨ The Opebi-Mende Link Road, a 3.680 km access link on the Mainland;
- ⇨ The Lekki Corridor, the improvement of the Epe Expressway and the construction of a new parallel facility in this corridor, namely the Coastal Freeway, both approximately 50 km in length (it also includes the construction of 10 interconnecting road links); and
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Another aspect, which was dealt with comprehensively is the willingness-to-pay toll fees and their affordability. This information was obtained through personal interviews and by means of stated preference (SP) surveys (revealed preference surveys could not be used since similar examples of tolling does not exist currently). Average hourly income levels were also obtained as another indication of the value of time (VOT).

2 STATED PREFERENCE SURVEYS

2.1 DESCRIPTION

Stated Preference Surveys (SP) was conducted to determine the choices of users when confronted with a toll road and alternative free roads. The results of these surveys were used to calibrate a standard discrete choice model – a Binary Logit Model – but also to determine the value of time (VOT) of road users. This value of time was used in the Generalized Cost Functions of the Transportation Planning Models to do the route assignment (and determined the attraction to the toll roads).

Although only the value of time in relation to toll fees was included in the SP surveys, the logit route choice models were adapted for application purposes to include vehicle operating cost (VOC). Only fuel cost was included in the VOC, since the road user rarely "perceives" the full cost of operating a vehicle, which includes financing and depreciation costs.

The probability to choose a route option, given the utility values for the respective route, is given by the following LOGIT formulae:

$P_i(x) = e^{Ui(x)} / (\sum_1^n (e^{Uh(x)}))$

Where

$P_i(x)$ = the probability to choose route i from n number of route options

$U_i(x)$ = the utility function for route i = K_i (x)*GC_i

K_i (x) = a calibration coefficient

GC_i = Generalised cost of route i

The utility functions could be formulated as generalized cost functions, travel time functions or both. To represent the non-tangible elements, route specific constants are added. The typical form for the generalised cost of a toll route is the following:

GC = Toll_Rate + Operating_Cost + Time_Cost + PB

The last term in this function could be seen as the aggregate of all perceived benefits (PB) not normally measurable, called the "motorway bonus".

2.2 METHODOLOGY

Two separate surveys were conducted:

- **<u>One on the Mainland amongst car owners whom travel regularly on the mainland as either a:</u>**
  - Commuter: must travel everyday or at least the majority of the week to a fixed work place
  - Business traveller: must make at least one trip for work purposes per week (to a meeting/ other business related travel by car)
  - For the purpose of shopping/entertainment/education: must make minimum of one trip per week for any of these purposes
  - Mini bus drivers: assuming taxi drivers work for the majority of week days so should travel at least 5 days a week with their mini bus.

- **<u>One along the Lekki Corridor amongst car owners whom travel regularly along the Lekki Corridor as either a:</u>**
  - Commuter: must travel everyday or at least the majority of the week to a fixed work place
  - Business traveller: must make at least one trip for work purposes per week (to a meeting/ other business related travel by car)
  - For the purpose of shopping/entertainment/education: must make minimum of one trip per week for any of these purposes
  - Mini bus drivers: assuming taxi drivers work for the majority of week days so should travel at least 5 days a week with their mini bus.

2.2.1 SAMPLE SIZE AND MARKET SEGMENTS

The total sample size was 3,200 questionnaires, which is statistically very significant taking into account the standard deviations in the data set. This was divided as follows:

- Mainland total sample: 1,600
  - 400 Commuters
  - 400 Business travellers

  - ♦ 400 Shopping/entertainment/education travellers
  - ♦ 400 Mini-bus drivers

- ⇨ Lekki Corridor total sample:1,600
  - ♦ 400 Commuters
  - ♦ 400 Business travellers
  - ♦ 400 Shopping/entertainment/education travellers
  - ♦ 400 Mini-bus drivers

2.2.2 RECRUITMENT

The majority of respondents were recruited using the intercept method: i.e. interception at strategic traveller areas such as; petrol stations, office car parks, shopping area car parks. In order to make the interviewing task easier for RMS, the client has provide the Market Research Company with a letter from the governor endorsing the need for this study.

Mini bus drivers were recruited at bus stands.

The questionnaire was completed on the spot if the respondent was willing to participate. This was the best and most cost effective method as opposed to pre-recruitment due to respondents' unwillingness to give out personal details or to be met at home. In addition, many of the people who were interviewed were "time-poor" resulting in a higher response rate if the questionnaires were completed on the spot.

If a respondent was willing to participate, but did not have the time, an appointment was made and the respondent was revisited at a later convenient time.

2.2.3 CAPTIVES

The number of captives, i.e. respondents who are not willing to switch from their current travel behaviour to one of the route scenarios, was specified as a maximum of 5% of the total number of completed questionnaires. A high proportion of captives results into too little variance in the data from which to estimate a good model.

2.2.4 PILOT STUDY

A pilot study of 200 (25 sample in each cell) interviews was first conducted to test and improve the questionnaires. One of the amendments from the pilot study was to lower the range in toll rates. It has also indicated that a 5% captive rate was difficult to achieve.

2.2.5 DESIGN OF CHOICE SET

Recruited respondents were confronted with a choice set of nine scenarios, which compared an existing route with the proposed new toll route. A reduction in fuel cost for the toll route compared to the existing route was stated as a fixed control variable across all nine choices. The SP variables consisted of an absolute time saving in minutes of the toll route compared to the existing (non-tolled) route, as well as a toll fee in Naira, the local currency. For each scenario, the recruit was then asked to choose between the two route options, the toll route and the existing route.

The SP design was kept simple, limited to two SP variables, in view of the interview time constraints, and the potentially high number of illiterate or semi-literate respondents in this Developing Country environment. A fractional orthogonal design of three levels of each of the two SP variables was specified.

Control information was presented in the introduction to the SP experiment to describe other benefits of the new toll road such as high road standard, well maintained, and safe travel conditions.

An example of the questionnaire is included as **Annexure A**.

2.3 VALUE OF TIME (VOT)

LOGIT Models were estimated based on the SP data, which are statistically highly significant. Table 2-3 gives the calibration results. Rho-Square values of segmented models range between 0.28 and 0.51, indicating highly significant models. Coefficients of variables are mostly significant at more than 95 per cent confidence level (t-value > 2). However, the value of time of business travellers was not always higher than the value of time of commuters (as can be expected). Similarly, the value of time of commuters was not always higher than shopping/entertainment/education trips as can be expected. International research indicated that values of time of business trips are typically higher than that of commuters, while values of time of commuters are typically higher than social/shopping/other trips.

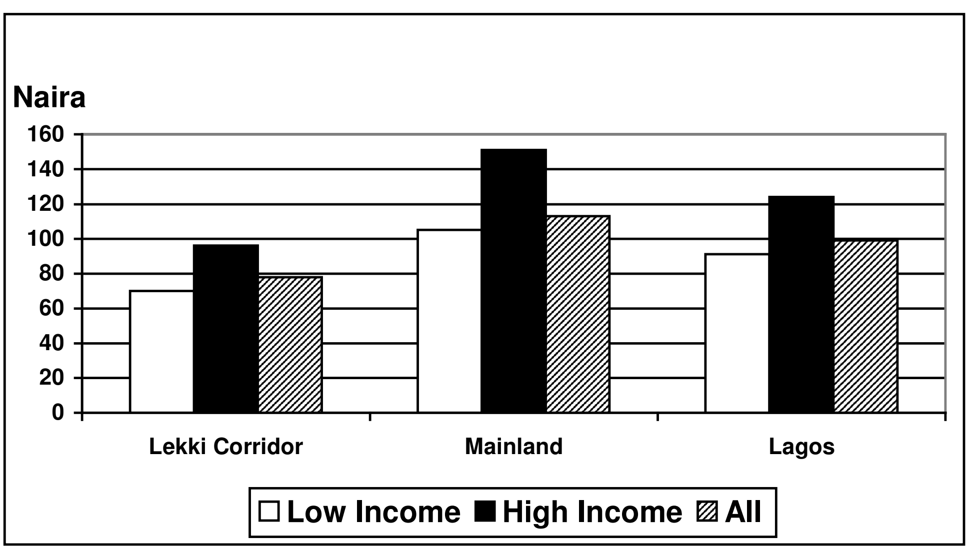
In addition, the value of time on the Mainland is higher than in the Lekki Corridor. Refer to Table 2-3. Given the nature and type of development in the Lekki Corridor, one would expect the opposite to be true. One possible explanation for the higher values of time on the Mainland is the higher current congestion levels – compared to the Lekki Corridor – which may influence respondents to put a higher value on their own time. However, by segmenting each trip purpose in the sample into low and high-income groups, it is found that the value of time of high-income respondents is higher than low-income respondents, which is intuitively correct.

The application of utility maximisation theory and SP models in developing countries are very complex and faces huge challenges, as indicated by various international research and empirical evidence (Van Zyl and Raza, 2004, Van Zyl, Lombard and Lamprecht, 2001). Problems of illiteracy, differences in perceptions of time by different cultures, language, possible differences in the behavioural basis of decision-making between Western and African cultures, SP policy-bias and other SP biases, are but a few of the problems facing planners. Other problems that may explain the anomalies are the fact that important factors impacting on route choice have been excluded from the experiment, such as fuel cost, interactions with mode choice, and the fact that road users in Lagos are not yet exposed to toll facilities, and hence not use to trade off paying toll fees to travel benefits.

The above anomalies are therefore not surprising, and while the good calibration results are giving one a certain sense of confidence in the results, it is important to explore alternative methods of estimating values of time to provide either support of the SP results, or to provide a range of results for use in sensitivity analyses. Often Revealed Preference surveys are used as a comparison with SP surveys, or for combining RP and SP surveys. In view of the fact that there are not existing toll facilities in Lagos, or elsewhere in Nigeria, this avenue was not an option. As indicated in a subsequent section, there were other more direct methods available to estimate values of time for benchmarking purposes.

In view of the above anomalies, and the fact that values of time do not range a lot between trip purposes, it was thus decided to combine the various market segments and to use a common value of time for both the Mainland and the Lekki Corridor.

Figure 2-1: Value of Time from SP



2.4 RESULTS AND INTERPRETATION

2.4.1 ONLY TIME COST

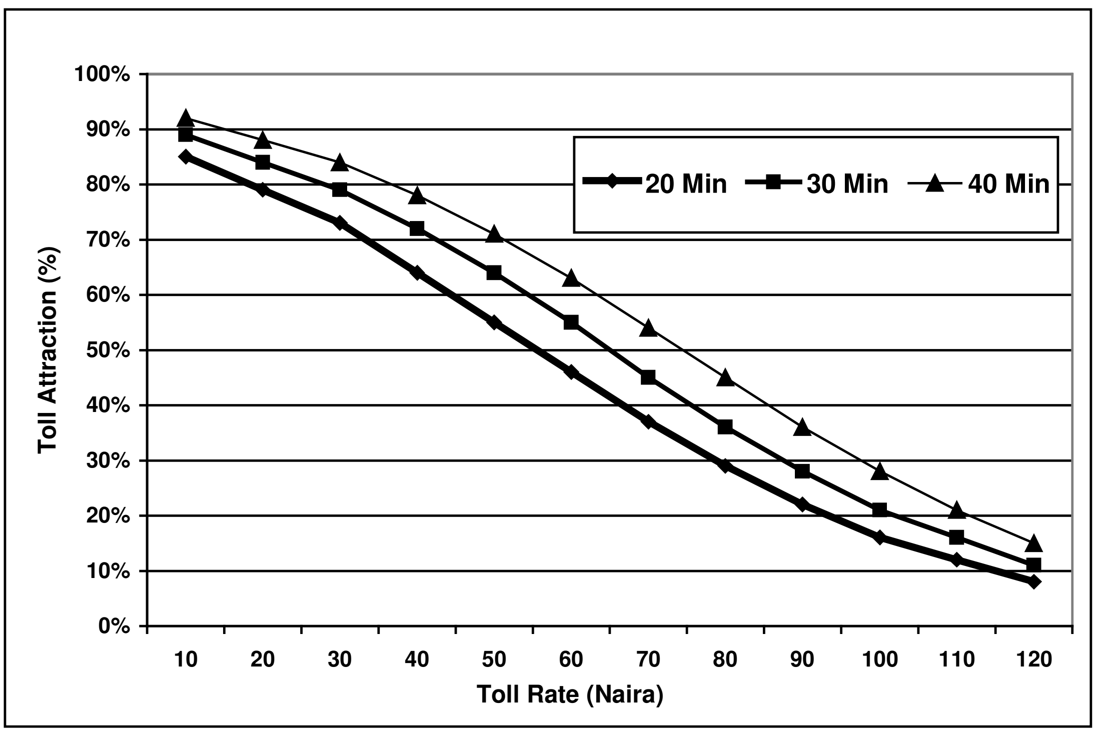
The following utility functions were obtained for the combined market segments, which yielded a VOT of 100 Naira per hour.

$U_{(toll\ road)}$ = 0.03478 x Time_Saving – 0.03748 x Toll_Rate

$U_{(alternative)}$ = -1.39900

These utility functions were used to produce the diversion curves shown in Figure 2-2. These curves show an attraction rate of 40% for a toll rate of 75 N and 20% for a toll rate of 100 N assuming a saving of 30 minutes in travel time. These attraction rates are deemed unreasonably low. However, the estimated utility functions from the SP experiment excluded the impact of fuel cost savings, in order to simplify the SP experiment. A second LOGIT model was hence formulated, based on the above time and cost coefficients, which includes vehicle-operating cost (fuel cost), as well.

Figure 2-2: Toll Diversion Curve: Only Time Cost



2.4.2 TIME COST AND FUEL COST

The following utility functions are obtained if the VOT (100 Naira per hour) and Fuel Cost (1 litre = 50 Naira) are assumed as variables in the utility function. Due to a lack of better information, it was assumed that the absolute coefficient value of Fuel cost saving would be similar to that of the Toll rate. (The sign of Fuel cost saving coefficient was made positive, as it has a positive impact, compared to Toll Rate, which has a negative impact).

$U_{(toll\ road)} = 0.03478 \times Time\_Saving + 0.03748 \times VOC\ Saving - 0.03748 \times Toll\_Rate$

$U_{(alternative)} = -1.39900$

These utility functions were used to produce the diversion curves shown in Figure 2-3. These curves show an attraction rate of 82% for a toll rate of 75 N and 64% for a toll rate of 100 N assuming a saving of 30 minutes in travel time. These attraction rates are considered more reasonable considering all the parameters.

Figure 2-3: Toll Diversion Curve: Time Cost and Fuel Cost

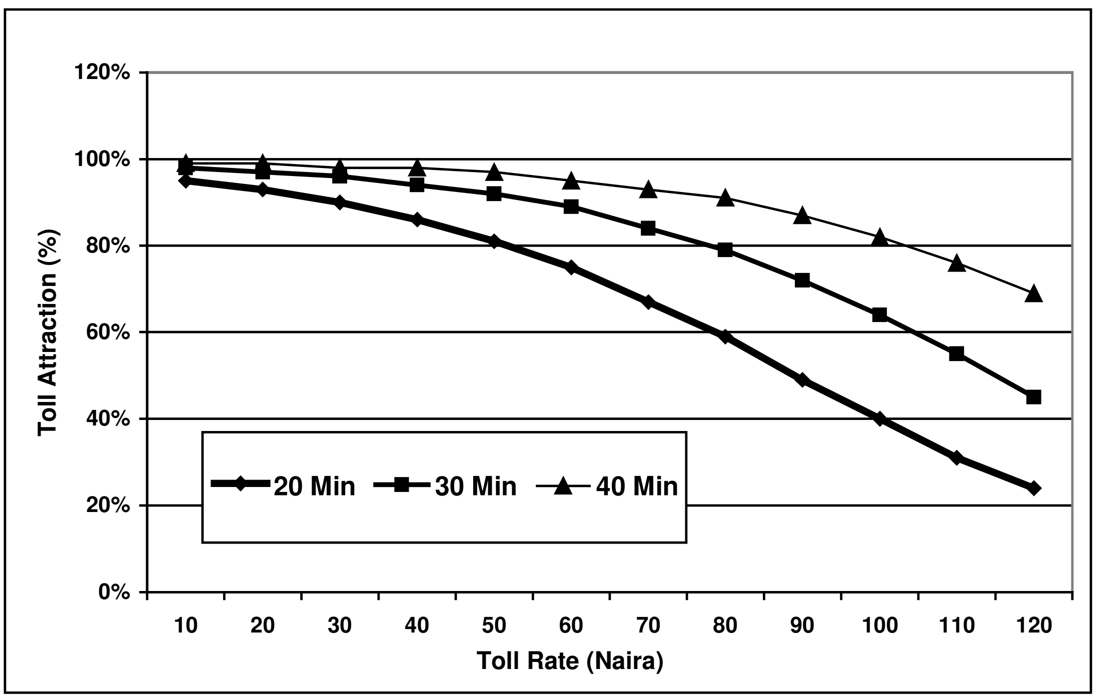


Figure 2-4 (attached) shows attraction rates of 40%, 65%, and 82% for savings of 20 minutes, 30 minutes, and 40 minutes in travel time respectively and a toll tariff of 100 Naira.

2.5 OTHER INFORMATION FROM INTERVIEWS

During the SP surveys, the opportunity was also used to obtain other useful information on:

- Income per month (also translated to income per hour);
- Willingness-to-pay for 20 minute saving in travel time (translated to an equivalent hourly value); and
- Average trip time.

Table 2-1 shows a summary of the average values for income per hour, willingness to pay, and average trip time. The detailed results of these surveys are shown in Table 2-5, Table 2-6, and Table 2-7 for the Mainland, Lekki Corridor, and these two areas combined. The results in these tables are given per market segment, and are aggregated.

Although income per hour is not necessary the same as value of time, it is sometimes used as a surrogate for value of time in the absence of any stated or revealed preference surveys.

In South Africa, the value of time is often found to be higher than average income levels. The opposite was however found with Stated Preference Studies done in India (Van Zyl and Raza, 2004).

Table 2-1: Salient Information from SP surveys

	MAINLAND	LEKKI CORRIDOR	COMBINED (LAGOS)
Average Income per hour	228 N / h	280 N / h	254 N / h
Willingness-to-Pay for 20-minute saving in travel time (equivalent hourly value)	253 N / h	303 N / h	278 N / h
Average stated travel time per trip	54 min	71 min	63 min

It is clear from Table 2-1 that both the income levels per hour and the willingness-to-pay levels are significant higher than the value of time (1 hour = ±100 N) calculated by means of the LOGIT models. It is also interesting to note that the Lekki Corridor yields higher values of time compared to Mainland, opposite to the SP results, which is in support of expectations.

2.6 OTHER VALUE OF TIME INDICATIONS

A Study was also conducted in 2001 by Stoveland Consult on “Willingness to Pay for Transport and Parking in Lagos, Nigeria”. The results of this study, although aimed at lower income public transport users, were subsequently compared with the results of the current study in terms of value of time (VOT).

Table 2-2: Value of Time (Naira per hour): Stoveland Consult, 2001

Different Approaches		All	Molue (Midibus)	Danfo (Minibus)	Taxi (Metered sedan cars)	Okada (Motor-cycles)	Train
Using multiple choice questions (direct question)	Study, 2001	57	32	40	161	66	60
	Adjusted 2005	68	38	47	191	78	71
Based on reduced travel time (indirect calculation)	Study, 2001	72	62	243	268	45	
	Adjusted 2005	85	74	288	318	53	

The users of taxis can probably be best compared with the users of private cars. Comparison of Table 2-1 (private users) and Table 2-2 (taxi users) shows a good agreement. It further confirms a higher value of time than the 100 Naira obtained from the LOGIT models.

2.7 CONCLUSION: VOT

Although the LOGIT Models (highly significant coefficients) have suggested an average VOT of 100 Naira per hour, other evidence suggests a significant higher value:

- ⇨ Average hourly income from SP surveys;
- ⇨ Willingness to pay questions from SP surveys;
- ⇨ Value of time of taxi users based on multiple choice questions by Stoveland Consult (2001);
- ⇨ Value of time of taxi users based on reduced travelling time by Stoveland Consult (2001).

A value of time of 100 Naira per hour was therefore adopted as a conservative (pessimistic) estimate and 200 Naira per hour as a realistic estimate.

2.8 REFERENCES

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2. Van Zyl, N.J.W., Lombard, M.C. and Lamprecht, T. "The Success of Stated Preference Techniques in Evaluating Travel Options for Less Literate Transport Users in a Developing Country with Specific Reference to South Africa", International Conference on Transport Survey Quality and Innovation, Kruger National Park, South Africa, 2001

Table 2-3: Results of SP Surveys: Detailed Segmentation

ROUTE	MARKET	SAMPLE SIZE	LOGIT COEFFICIENTS: TIME SAVE	TIME SAVE LOW INC	TIME SAVE HIGH INC	TOLL	CON-STANT Alt Route	RHO SQUARED	VOT N PER HR	VOT LOW INC N PER HR	VOT HIGH INC N PER HR	TOLL BONUS N	TRIP TIME HR	TOLL BONUS N PER HR	TOT VOT N PER HR	TOT VOT LOW INC N PER HR	TOT VOT HIGH INC N PER HR
Lekki Corridor	Commuter all	4824	0.01961			-0.03079	-1.029	0.28	38			33	1	33	**72**		
	T Ratio		8.0			-30.8	-12.4										
Lekki Corridor	Commuter excl. captives	4158	0.02547			-0.03530	-1.530	0.35	43			43	1	43	**87**		
	T Ratio		9.0			-31.1	-16.3										
Lekki Corridor	Commuter excl. captives	4158		0.02266	0.02865	-0.03536	-1.531	0.35		38	49	43	1	43		82	92
	T Ratio			7.2	8.8	-31.1	-16.3										
Lekki Corridor	Business excl. captives	6129	0.02634			-0.05032	-1.903	0.43	31			38	1	38	**69**		
	T Ratio		10.6			-33.4	-20.6										
Lekki Corridor	Business excl. captives	6129		0.02158	0.05589	-0.05146	-1.930	0.44		25	65	38	1	38		63	103
	T Ratio			8.4	13.0	-33.8	-20.8										
Lekki Corridor	Education excl. captives	252	0.02993			-0.03303	-1.288	0.33	54			39	1	39	**93**		

			LOGIT COEFFICIENTS							VOT	VOT	TOLL	TRIP	TOLL	TOT VOT	TOT VOT	TOT VOT
ROUTE	MARKET	SAMPLE SIZE	TIME SAVE	TIME SAVE LOW INC	TIME SAVE HIGH INC	TOLL	CON-STANT Alt Route	RHO SQUARED	VOT N PER HR	LOW INC N PER HR	HIGH INC N PER HR	BONUS N	TIME HR	BONUS N PER HR	N PER HR	LOW INC N PER HR	HIGH INC N PER HR
	T Ratio		2.6			-7.7	-3.5										
Lekki Corridor	Shopping excl. captives	2484	0.02228			-0.03383	-1.446	0.33	40			43	1	43	**82**		
	T Ratio		6.2			-23.7	-12.1										
Mainland	Commuter all	3801	0.03117			-0.03078	-1.113	0.39	61			36	0.75	48	**109**		
	T Ratio		12.4			-29.9	-10.2										
Mainland	Commuter excl. captives	3504	0.03668			-0.03439	-1.447	0.44	64			42	0.75	56	**120**		
	T Ratio		13.2			-29.4	-12.0										
Mainland	Commuter excl. captives	3504		0.03211	0.06565	-0.03615	-1.510	0.47		53	109	42	0.75	56		109	165
	T Ratio			11.2	15.1	-29.4	-12.4										
Mainland	Business excl. captives	6514	0.04163			-0.04391	-1.587	0.51	57			36	0.75	48	**105**		
	T Ratio		18.2			-38.8	-16.8										
Mainland	Business excl. captives	6514		0.03865	0.06387	-0.04471	-1.611	0.52		52	86	36	0.75	48		100	134

ROUTE	MARKET	SAMPLE SIZE	LOGIT COEFFICIENTS: TIME SAVE	LOGIT COEFFICIENTS: TIME SAVE LOW INC	LOGIT COEFFICIENTS: TIME SAVE HIGH INC	LOGIT COEFFICIENTS: TOLL	LOGIT COEFFICIENTS: CON-STANT Alt Route	LOGIT COEFFICIENTS: RHO SQUARED	VOT N PER HR	VOT LOW INC N PER HR	VOT HIGH INC N PER HR	TOLL BONUS N	TRIP TIME HR	TOLL BONUS N PER HR	TOT VOT N PER HR	TOT VOT LOW INC N PER HR	TOT VOT HIGH INC N PER HR
	T Ratio			16.6	17.9	-39.0	-16.9										
Mainland	Education excl. captives	270	0.03602			-0.03782	-1.703	0.48	57			45	0.75	60	**117**		
	T Ratio		3.5			-8.1	-3.7										
Mainland	Shopping excl. captives	2583	0.03435			-0.03099	-1.351	0.41	67			44	0.75	58	**125**		
	T Ratio		11.1			-25.5	-10.1										
Mainland	Taxi excl. captives	270	0.02170			-0.09355	-6.317	0.83	14			68	0.75	90	**104**		
	T Ratio		0.1			-8.1	-5.3										

Notes: All models and variables are highly significant, except for time saving for the taxi segment on the Mainland corridor

Not significant

Table 2-4: Results of SP Surveys: Combined Segmentation

			LOGIT COEFFICIENTS														
ROUTE	MARKET	SAMPLE SIZE	TIME SAVE	TIME SAVE LOW INC	TIME SAVE HIGH INC	TOLL	CON-STANT Alt Route	RHO SQUARED	VOT N PER HR	VOT LOW INC N PER HR	VOT HIGH INC N PER HR	TOLL BONUS N	TRIP TIME HR	TOLL BONUS N PER HR	TOT VOT N PER HR	TOT VOT LOW INC N PER HR	TOT VOT HIGH INC N PER HR
Lekki Corridor	All data excl. captives	13095	0.02491			-0.03991	-1.610	0.38	37			40	1	40	78		
	T Ratio		15.3			-52.3	-28.8										
Lekki Corridor	All data excl. captives	13095		0.01995	0.03720	-0.04032	-1.621	0.39		30	55	40	1	40		70	96
	T Ratio			11.7	17.3	-52.4	-29.0										
Mainland	All data excl. captives	13573	0.03685			-0.03759	-1.517	0.47	59			40	0.75	54	113		
	T Ratio		25.3			-56.9	-24.1										
Mainland	All data excl. captives	13573		0.03309	0.06294	-0.03882	-1.558	0.48		51	97	40	0.75	54		105	151
	T Ratio			22.2	27.2	-57.3	-24.5										
Lagos Comb.	All data excl. captives	26668	0.03478			-0.03748	-1.399	0.42	56			37	0.87	43	99		
	T Ratio		33.2			-79.4	-36.5										

ROUTE	MARKET	SAMPLE SIZE	LOGIT COEFFICIENTS TIME SAVE	TIME SAVE LOW INC	TIME SAVE HIGH INC	TOLL	CON-STANT Alt Route	RHO SQUARED	VOT N PER HR	VOT LOW INC N PER HR	VOT HIGH INC N PER HR	TOLL BONUS N	TRIP TIME HR	TOLL BONUS N PER HR	TOT VOT N PER HR	TOT VOT LOW INC N PER HR	TOT VOT HIGH INC N PER HR
Lagos Comb.	All data excl. captives	26668		0.03121	0.05195	-0.03797	-1.390	0.43		49	82	37	0.87	42		91	124
	T Ratio			29.1	33.8	-79.5	-36.1										
				LEKKI TIME	**MAINL TIME**					**LEKKI**	**MAIN LAND**					**LEKKI**	**MAIN LAND**
Lagos Comb.	All data Lekki vs Mainland	26668		0.02434	0.03777	-0.03862	-1.560	0.42		38	59	40	0.87	46		84	105
	T Ratio			18.1	34.6	-77.5	-37.7										
Notes: All models and variables are highly significant.																	

Figure 2-4: Toll Attraction based on Diversion Curves

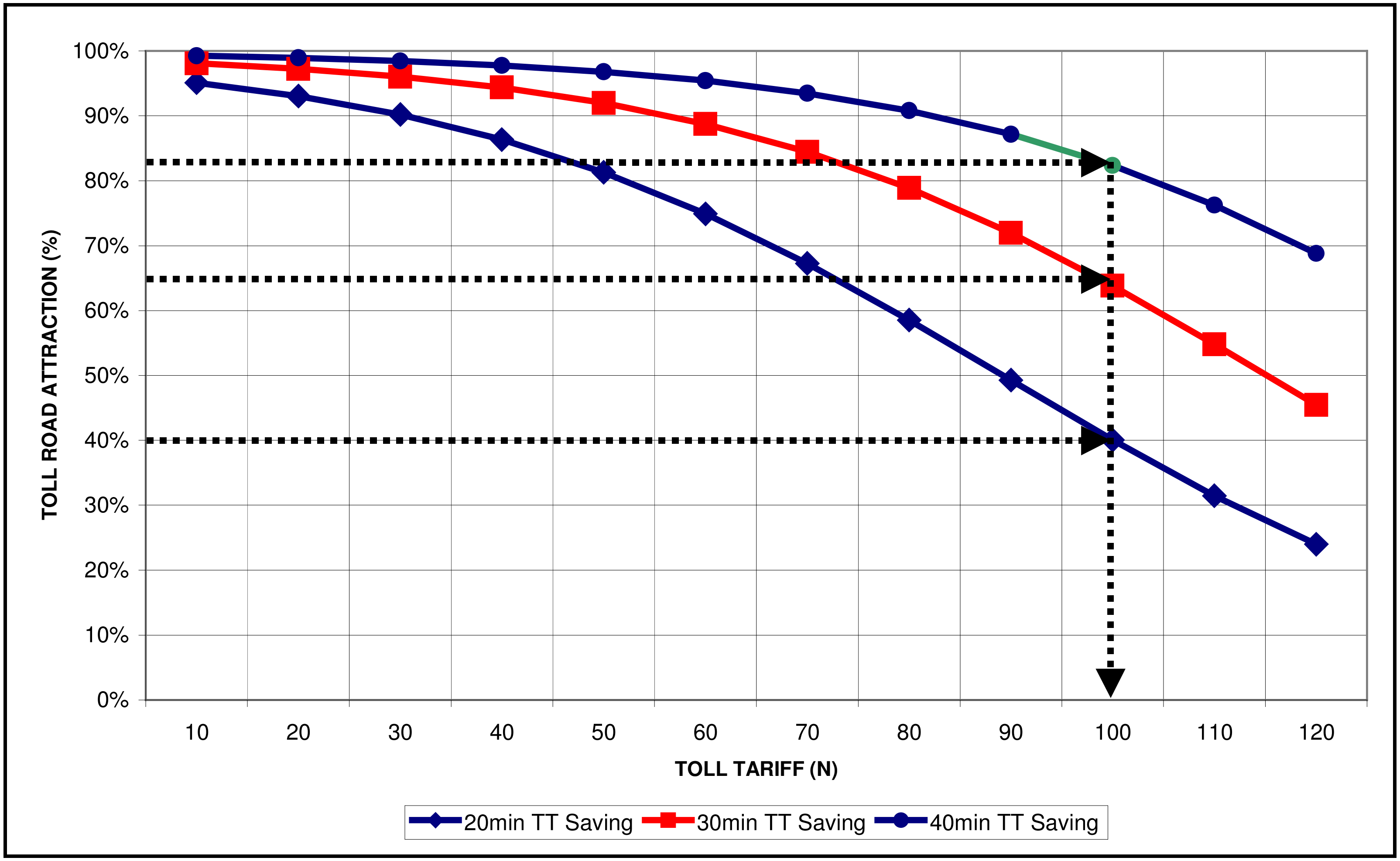


Table 2-5: SP Mainland: Results of Roadside Interviews

		All			Commuter			Business			Education			Shopping/ Entertainment			Minibus (Mainland Only)		
		Freq	%	Cum %	Freq	%	Cum %	Freq	%	Cum %	Freq	%	Cum %	Freq	%	Cum %	Freq	%	Cum %
Income N/Month	Less than N20 000	334	22%	22%	80	20%	20%	170	22%	22%	7	22%	22%	63	22%	22%	0	0%	0%
	N20 000 to N50 000	901	60%	82%	238	58%	78%	465	61%	84%	24	75%	97%	160	56%	78%	14	88%	88%
	N50 000 to N100 000	254	17%	98%	79	19%	97%	117	15%	99%	1	3%	100%	56	20%	98%	1	6%	94%
	More than N100 000	25	2%	100%	11	3%	100%	6	1%	100%	0	0%	100%	7	2%	100%	1	6%	100%
	Total	1514			408			758			32			286			16		
	Mean	36,496			39,154			35,119			29,688			38,304			25,167		
	Median	35,000			35,000			35,000			35,000			35,000			35,000		
	Standard Deviation	24,175			25,796			22,509			15,024			26,074			25,274		
Income N/h	Mean	228			245			219			186			239			157		
	Median	219			219			219			219			219			219		
	Standard Deviation	151			161			141			94			163			158		
W-t-P	Less than N25	33	2%	2%	9	2%	2%	15	2%	2%	1	3%	3%	8	3%	3%	0	0%	0%
	N25 to N50	313	21%	24%	70	18%	20%	175	24%	26%	8	26%	29%	54	19%	21%	6	21%	21%
	N50 to N75	589	40%	64%	168	43%	63%	282	39%	65%	14	45%	74%	111	38%	60%	14	48%	69%

	More than N75	533	36%	100%	143	37%	100%	257	35%	100%	8	26%	100%	116	40%	100%	9	31%	100%
	Total	1468			390			729			31			289			29		
	Mean	84.29			88.13			79.90			83.71			91.97			67.24		
	Median	60.00			60.00			60.00			60.00			60.00			60.00		
	Standard Deviation	81.50			78.88			83.07			103.47			81.37			30.69		
Trip Time	Less than 30min	422	27%	27%	96	23%	23%	200	26%	26%	8	24%	24%	110	37%	37%	8	27%	27%
	30min to 60min	809	52%	79%	235	56%	78%	399	52%	78%	19	58%	82%	137	46%	84%	19	63%	90%
	60min to 90min	207	13%	93%	55	13%	91%	115	15%	93%	3	9%	91%	31	11%	94%	3	10%	100%
	More than 90min	113	7%	100%	37	9%	100%	56	7%	100%	3	9%	100%	17	6%	100%	0	0%	100%
	Total	1551			423			770			33			295			30		
	Mean	54.07			56.07			54.72			56.36			49.92			47.67		
	Median	50.00			50.00			50.00			60.00			45.00			50.00		
	Standard Deviation	29.88			30.06			28.51			30.96			33.53			16.44		

Table 2-6: SP Lekki Corridor: Results of Roadside Interviews

		All			Commuter			Business			Education			Shopping/ Entertainment			Minibus (Mainland Only)		
		Freq	%	Cum %	Freq	%	Cum %	Freq	%	Cum %	Freq	%	Cum %	Freq	%	Cum %	Freq	%	Cum %
Income N/Month	Less than N20 000	385	25%	25%	66	13%	13%	269	38%	38%	10	32%	32%	40	14%	14%			
	N20 000 to N50 000	639	41%	66%	203	39%	51%	290	41%	80%	14	45%	77%	132	46%	61%			
	N50 000 to N100 000	387	25%	91%	192	36%	87%	105	15%	95%	5	16%	94%	85	30%	90%			
	More than N100 000	132	9%	100%	66	13%	100%	37	5%	100%	2	6%	100%	27	10%	100%			
	Total	1543			527			701			31			284					
	Mean	44,819			56,461			33,966			37,258			50,827					
	Median	35,000			35,000			35,000			35,000			35,000					
	Standard Deviation	33,886			33,794			31,091			32,297			32,337					
Income N/h	Mean	280			353			212			233			318					
	Median	219			219			219			219			219					
	Standard Deviation	212			211			194			202			202					
W-t-P	Less than N25	22	2%	2%	5	1%	1%	13	2%	2%	1	4%	4%	3	1%	1%			
	N25 to N50	195	14%	15%	47	10%	11%	116	17%	19%	5	18%	21%	27	10%	11%			

	N50 to N75	696	49%	64%	206	45%	57%	342	50%	69%	10	36%	57%	138	51%	63%			
	More than N75	519	36%	100%	197	43%	100%	210	31%	100%	12	43%	100%	100	37%	100%			
	Total	1432			455			681			28			268					
	Mean	101.01			113.61			93.08			104.46			99.38					
	Median	60.00			60.00			60.00			60.00			60.00					
	Standard Deviation	97.98			98.59			104.73			114.27			72.37					
Trip Time	Less than 30min	337	21%	21%	89	17%	17%	170	23%	23%	6	19%	19%	72	25%	25%			
	30min to 60min	650	41%	62%	210	39%	56%	298	41%	64%	13	42%	61%	129	44%	69%			
	60min to 90min	270	17%	79%	114	21%	77%	110	15%	79%	8	26%	87%	38	13%	82%			
	More than 90min	333	21%	100%	123	23%	100%	153	21%	100%	4	13%	100%	53	18%	100%			
	Total	1590			536			731			31			292					
	Mean	71.10			75.37			70.68			65.00			64.99					
	Median	60.00			60.00			60.00			60.00			60.00					
	Standard Deviation	42.80			41.47			45.45			31.62			38.48					

Table 2-7: SP Combined Surveys: Results of Roadside Interviews

		All			Commuter			Business			Education			Shopping/ Entertainment			Minibus (Mainland Only)		
		Freq	%	Cum %	Freq	%	Cum %	Freq	%	Cum %	Freq	%	Cum %	Freq	%	Cum %	Freq	%	Cum %
Income N/Month	Less than N20 000	719	24%	24%	146	16%	16%	439	30%	30%	17	27%	27%	103	18%	18%	14	47%	47%
	N20 000 to N50 000	1540	50%	74%	441	47%	63%	755	52%	82%	38	60%	87%	292	51%	69%	14	47%	93%
	N50 000 to N100 000	641	21%	95%	271	29%	92%	222	15%	97%	6	10%	97%	141	25%	94%	1	3%	97%
	More than N100 000	157	5%	100%	77	8%	100%	43	3%	100%	2	3%	100%	34	6%	100%	1	3%	100%
	Total	3057			935			1459			63			570			30		
	Mean	40,697			48,909			34,565			33,413			44,544			25,167		
	Median	35,000			35,000			35,000			35,000			35,000			35,000		
	Standard Deviation	29,767			31,732			26,972			25,142			29,998			25,274		
Income N/h	Mean	254			306			216			209			278			157		
	Median	219			219			219			219			219			219		
	Standard Deviation	186			198			169			157			187			158		
W-t-P	Less than N25	55	2%	2%	14	2%	2%	28	2%	2%	2	3%	3%	11	2%	2%	0	0%	0%
	N25 to N50	508	18%	19%	117	14%	16%	291	21%	23%	13	22%	25%	81	15%	17%	6	21%	21%

	N50 to N75	1285	44%	64%	374	44%	60%	624	44%	67%	24	41%	66%	249	45%	61%	14	48%	69%
	More than N75	1052	36%	100%	340	40%	100%	467	33%	100%	20	34%	100%	216	39%	100%	9	31%	100%
	Total	2900			845			1410			59			557			29		
	Mean	92.55			101.85			86.27			93.56			95.54			67.24		
	Median	60.00			60.00			60.00			60.00			60.00			60.00		
	Standard Deviation	90.39			90.87			94.35			108.29			77.19			30.69		
Trip Time	Less than 30min	759	24%	24%	185	19%	19%	370	25%	25%	14	22%	22%	182	31%	31%	8	27%	27%
	30min to 60min	1459	46%	71%	445	46%	66%	697	46%	71%	32	50%	72%	266	45%	76%	19	63%	90%
	60min to 90min	477	15%	86%	169	18%	83%	225	15%	86%	11	17%	89%	69	12%	88%	3	10%	100%
	More than 90min	446	14%	100%	160	17%	100%	209	14%	100%	7	11%	100%	70	12%	100%	0	0%	100%
	Total	3141			959			1501			64			587			30		
	Mean	62.70			66.86			62.49			60.55			57.42			47.67		
	Median	60.00			60.00			60.00			60.00			50.00			50.00		
	Standard Deviation	37.95			38.09			38.54			31.33			36.83			16.44		

3 LAND USE PLANNING AND FUTURE GROWTH IN STUDY AREA

3.1 CURRENT AND HISTORICAL PLANNING AND INFORMATION

Various traffic and transportation planning studies have been conducted in the Lagos area during the last decade. The most prominent of these, from a traffic perspective, is the following:

- ⇨ Master Plan for Metropolitan Lagos, by Wilbur Smith and Associates
- ⇨ Mass Transit and Management Programme for the Lagos Metropolitan Area, by Dar Al-Handasah, during 1992 to 1994
- ⇨ Traffic Study by LAMATA, during 2002
- ⇨ Willingness to Pay Survey for Public Transport, by Stoveland Consult, during 2001

3.1.1 MASTER PLAN FOR METROPOLITAN LAGOS (WILBUR SMITH & ASSOCIATES)

Wilbur Smith and Associates developed a Gravity Model for Metropolitan Lagos (utilising 12 traffic zones) to predict future traffic demand for compiling the Master Plan for Metropolitan Lagos. The base year of their study was 1979, and an annual population growth of 5.4% per annum was assumed to model the traffic demand for 2000.

The development of a Gravity Model is probably the most accurate way to determine the true traffic demand of Lagos and to predict future changes. Unfortunately, it also requires a very large amount of data. Another underlying assumption by Wilber Smith was that forecast year volumes across selected screen lines will exhibit inclinations proportional to base year traffic volumes, and all changes to the forecast year system should be interpreted as new facilities. In reality, capacities on the road network did not keep up with the increasing demand, which inevitably affected the distribution of trips since many major routes have become hardly negotiable in peak periods due to excessive congestion.

Predicted traffic volumes for 2000 for the Gravity Model were extracted from the Master Plan (Volume 1), and selected volumes are summarised below:

Table 3-1: Lagos Master Plan – Forecasted Traffic Volumes (2000)

Location	24-Hour Traffic Volume (two-way)
Eko Bridge	151,660
Carter Bridge	110,000
3rd Mainline Bridge	94,350
Epe Expressway	110,300

At the time when the Master Plan was compiled (early 1980's), it was foreseen that the major road network (freeways / expressways, arterials and collectors) would have to increase from 350km at the time to almost 1400km in 2000 to accommodate the expected growth in traffic. It was also proposed that traffic signalisation should be implemented at a rate of 20 intersections per year from 1986, to reach a number of 300 signalised intersections by 2000. Very few of these improvements envisaged in the Master Plan have however been implemented. Another obvious solution, mass transit through rapid rail, was also evaluated as a means of dealing with the demand for transport – this remains a dream.

3.1.2 MASS TRANSIT AND MANAGEMENT PROGRAMME FOR THE LAGOS METROPOLITAN AREA (DAR AL-HANDASAH)

A Mass Transit and Transport Systems Management Programme and Master Plan were developed for the Lagos Metropolitan Area in the period 1992 to 1994. Extensive traffic surveys were conducted as part of this study and comprised, among other things, Automatic Traffic Counts (ATC), Manual Classified Counts (MCC) and Traffic Movements Counts (TMC). Approximately 125 locations were surveyed on the Mainland and Lagos / Ikoyi Islands.

Some the traffic survey results, of which the locations correspond to those done by AFRICON-BKS, are summarised below:

Table 3-2: Surveyed Traffic Volumes – Dar Al-Handasah (1992)

Location	24-Hour Volume	AM Peak Hour Volume	AM Peak Hour as % of 24-Hour vol	PM Peak Hour Volume	PM Peak Hour as % of 24-Hour vol
Eko Bridge	107,300	6,568	6.1%	6,827	6.4%
Carter Bridge	51,900	4,107	7.9%	3,075	5.9%
3rd Axial Bridge	94,900	7,811	8.2%	6,840	7.2%
Ikorodu Road	77,000	5,858	7.6%	5,024	6.5%

The selected routes shown above were already heavily congested, with V/C ratios calculated (by Dar Al-Handasah) as follows:

Table 3-3: Volume/Capacity Ratios – Dar Al-Handasah (1992)

Location	Critical Hour V/C Ratios
Eko Bridge	0.98
Carter Bridge	0.87 (southbound) 0.41 (northbound)
3rd Axial Bridge	1.33
Ikorodu Road	0.89
Bank Anthony	0.60

The observed vehicle classification for the survey locations in **Table 3-2** were as follows:

Table 3-4: Vehicle Classification – Dar Al-Handasah (1992)

Location	Motor-cycles	Cars	Taxi	Minibus	Buses	Heavy (2-axle)	Heavy (3-axle)	Heavy (>3-axle)	TOT
3rd Axial	1.4%	86.9%	6.5%	1.1%	3.0%	0.9%	0.1%	0.1%	**100%**
Carter Bridge	2.8%	59.5%	11.5%	4.8%	19.8%	1.3%	0.1%	0.2%	**100%**
Eko Bridge	4.1%	76.4%	8.9%	3.5%	6.0%	0.8%	0.1%	0.1%	**100%**
Ikorodu Rd	1.2%	73.1%	6.1%	10.5%	6.1%	2.0%	0.2%	0.9%	**100%**

Traffic growth rates were determined for the purpose of the Mass Transit study, considering that the depressed stage of the economy at that stage did not seem likely to reverse, and that the low income group of the population (68%) would not experience a real increase in earnings and no significant change in their trip rate per capita was foreseen. It was also assumed that there would be no fundamental shift from public to private transport in the immediate future.

It was thus considered that the traffic growth would be fuelled almost exclusively by population growth. Different traffic growth rates were determined on different links on the road network, fundamentally based on sectoral population growths throughout Lagos State. It inevitably follows that higher traffic growth rates were calculated for the far western and north-western areas due to the higher propensity for population growth in these areas.

Two traffic growth rates were estimated for two consecutive 5-year periods from 1991 to 2001, for a number of different links on the Lagos State road network. These rates, excluding those for the less developed areas towards the urban perimeter, ranged in the order of 3% to 5% for the first 5 years (1991 to 1996), and 2% to 4% for 1996 to 2001. The growth rates proposed for selected locations, also surveyed by AFRICON-BKS in 2003, are shown below:

Table 3-5: Forecasted Traffic Growth Rates – Dar Al-Handasah (1992)

Period	Location	Forecasted Growth Rates
1991 to 1996	Eko Bridge	5.1%
	Carter Bridge	
	3rd Axial Bridge	
	Ikorodu Road	5.3%
1996 to 2001	Eko Bridge	3.8%
	Carter Bridge	
	3rd Axial Bridge	
	Ikorodu Road	5.9%

3.1.3 TRAFFIC STUDY BY LAMATA

The main objective of the traffic counts in this study was to provide the base data on the movement of vehicles on the high priority public transport road network. The following traffic counts were conducted between January 2002 and May 2002:

- Manual Classified Counts (MCC).
- Limited Automatic Traffic Counts (ATC) since attempts to set up permanent ATC stations for considerable duration were hampered by the illicit tampering of the sensor tubes and unsafe environment for the counters.
- Turning Movement Counts (TMC).

The data deduction and analysis programme has been largely directed towards the requirements for comparing the main corridor traffic with traffic volumes on the secondary roads to identify the extent of public transport utilization of such roads and for conducting an economic analysis based on the World Bank's HDM Model.

Traffic data at locations that corresponded to those surveyed by Dar Al-Handasah and AFRICON-BKS were selected for the purpose of comparison in Table 3-6:

Table 3-6: 12-Hour Traffic Volumes across Lagos Lagoon

Location	Direction	1992 (Dar Al-Handasah)	2002 (LAMATA)
Eko Bridge	Northbound Southbound	40,437 49,418	27,437 43,620
Carter Bridge	Northbound Southbound	29,930 15,435	38,628 13,501
Third Mainland Bridge	Northbound Southbound	40,862 49,178	46,543 42,930
Total		**225,260**	**212,656**

It is evident that traffic counts observed in 2002 were generally lower than those observed by Dar Al-Handasah in 1992. This was attributed to a combination of the following:

⇨ The deteriorated condition of some of the roads since 1992 and lack in appropriate maintenance, thereby necessitating the use of alternative routes to avoid heavily congested routes.

⇨ Reduction in the number of private vehicles due to the downturn in the economy over the preceding 10 years. However, the reduction in private vehicles has been compensated for by an increase in demand for Public Transport vehicles as observed by the screen line volumes in both directions, of the three Mainland-Island connecting bridges, as is shown in the Table 3-7.

⇨ The encroachment of roadways by traders.

⇨ Since 1992, the majority of the Government Departments moved to Abuja, resulting in a considerable reduction in vehicular traffic in Lagos.

⇨ Expansion and spreading of Corporate and Commercial organizations across the whole Lagos Metropolis as opposed to concentration in the Island.

Table 3-7: 12-Hour Classified Traffic volumes crossing Lagos Lagoon

Description	1992 (Dar Al-Handasah)			2002 (LAMATA)		
	Private vehicles	Public Transport Vehicles	Total	Private vehicles	Public Transport Vehicles	Total
Traffic crossing Eko, Carter & 3rd Mainland Bridges	168,132 *(77%)*	49,450 *(23%)*	217,582 *(100%)*	130,544 *(65%)*	70,866 *(35%)*	201,410 *(100%)*

A summary of historic traffic data related to the Opebi-Mende Link Road is given in Table 3-8.

Table 3-8: Historic Traffic Data in Opebi-Mende Study Area

Year	3rd Mainland Bridge	Source	Ikorodu Road	Source
1992	94 900	Dar Al-Handasah	77 000	Dar Al-Handasah
2003	103 679	BKS Traffic Surveys (2003)		
2004			74 175	BKS Traffic Surveys (2004)
Number of years	11		12	
Annual growth	0.8%		-0.3%	

Although Table 3-8 only contains data on two roads in the Opebi-Mende study area, it indicates a low traffic growth per year.

3.1.4 WILLINGNESS TO PAY SURVEY FOR PUBLIC TRANSPORT, STOVELAND CONSULT

A study was conducted by Stoveland Consult in November 2001 to evaluate the willingness to pay for public transport services in Lagos, with the aim of determining the feasibility of improvements to services in the public transport sector. Since the surveys were very project specific, not all results were of relevance to the question of how willing road users will be to pay for improved levels of service on tolled roads. However, some interesting results are extracted for the purpose of this report.

The main benefit of the proposed toll road projects will be a reduction in travel time to the general road user. Although the willingness to pay surveys was aimed at public transport users only, this information is still valuable to the current investigation. Toll fees paid by

PSV operators on toll roads will inevitably filter through to the passengers in the form of fare increases. The outcome of surveys for the willingness to pay for a reduction of 50% in travel time is summarised below:

Table 3-9: Willingness to Pay to Reduce Travel Time by 50%

Statistical Parameter	Willingness to Pay, as percentage of current fares				
	Molue	Danfo	Taxi	Okada	Train
Average	179%	156%	124%	170%	145%
Standard Deviation	99%	50%	26%	163%	51%

The statistics from the surveys indicate that public transport users are willing to pay in the order of 50% more if their travel time could be halved.

3.2 FUTURE LAND USE PLANNING AND TRAFFIC GROWTH

Very little area specific growth rate data exists for Lagos and surrounding areas. Investigation in historic traffic volume data was inconclusive due to differences in location of counts, classification of vehicles and fluctuations in economic growth.

Productions and attractions is a function of the trip ends for each zone. It depicts the traffic volumes on roads in the network. By applying growth rates to the productions and attractions of zones in the study area, traffic growth is generated on the road network.

Attractions are a function of the economic activity of a zone, and are thus closely linked to the gross regional product (GRP) of an area.

The low-income group of the population (68%) would not experience a real increase in earnings and no significant change in their trip rate per capita was foreseen. It was also assumed that there would be no fundamental shift from public to private transport in the future. It was thus considered that the growth in productions would be fuelled almost exclusively by population growth and the growth in attractions by economic growth.

Table 3-10 shows national GDP and population growth rates for the past few years. The United Nations Department of Economic and Social Affairs predicts an average annual population growth rate of 5.0% and 3.9% for 2000-2005 and 2010-2015 respectively for the agglomeration of Lagos.

Table 3-10: National Growth Rates

Year	GDP growth (annual %)	Population growth (annual %)
1999	1.10	2.52
2000	4.20	2.40
2001	2.90	2.31
2002	1.55	2.22
2003	10.61	2.12

**Source: World Bank Web Site*

According to Lagos State Water Company (LSWC) the estimated population growth rates for the southern part of the Mainland (Zone1), Lagos Island, Ikoyi, Victoria Island and Annex (Zone 2 to 6) and Lekki (Zone 7 to 12) is 1.55%, 1.14% and 16.6% respectively.

Different production and attraction growth rates were determined for different zones in the study area, fundamentally based on sectoral population growth rates and economic activities throughout the area. It inevitably follows that higher growth rates in productions were calculated for zones with lower levels of population due to the higher propensity for population growth of these areas and similarly higher growth rates in attractions were calculated for zones with higher levels of development due to the propensity for higher levels of economic activities in these areas.

The expected growth rates of the Lekki Corridor with an abundance in vacant land and being the preferred location for developers is much higher than those of the Mainland which is basically saturated.

The Opebi-Mende study area consists mostly of townships and commercial areas, with limited open spaces. The development potential of the Mainland in general is low, given that very limited vacant land is available and all the utilities – most importantly roads – are operating at saturated levels.

Traffic growth in a region however is related to the growth of the population in the region as well as the growth in GDP. When consulting documentation for Nigeria, the following forecasts regarding population and GDP are obtained:

- ⇨ The latest figures for real GDP growth rates for Nigeria indicates a growth of 4.6% for 2001 and 3.5% for 2002 (Federal Office of Statistics, 2004)
- ⇨ Population growth in Nigeria, according to the CIA World Fact Book, is 2.5% pa (2004 estimate).

4 TOLL STRATEGY

4.1 OPEN TOLL STRATEGIES

Open toll strategies are planned for both projects based on the relatively low cost. The plazas are therefore located to balance the need for equitability (shorter sections are more equitable since they include less "averaging") and the desirable minimum number of stops and thus plazas.

4.2 TOLL RATES AND TOLL CLASSES

Four toll classes were assumed, namely Class I light vehicles, Class II heavy vehicles with two axles, Class III heavy vehicles with 3 and 4 axles, and Class IV heavy vehicles with 5 and more axles. The assumed ratios between toll rates for toll classes are 2.5, 3, and 4 respectively for toll classes 2, 3, and 4 relative to toll class 1:

- ⇨ Toll Class 1 1
- ⇨ Toll Class 2 2.5
- ⇨ Toll Class 3 3
- ⇨ Toll Class 4 4

These ratios are based on the South African approach, which is a compromise between the actual cost imposed on the road network by different vehicle class and an attempt to keep tariffs affordable for the heavy vehicle classes. The actual cost imposed by heavy vehicles is 13 times more than the cost imposed by a light vehicle but experience has shown that heavy vehicles are not prepared to pay these high rates.

4.3 TOLL MECHANISM

The relatively high traffic volumes that must be tolled combined with the requirement for a "cashless" system resulted in two payment strategies; namely electronic tolling (ETC) for the higher end of the market and a debit "pay-as-you-go" tolling card for the lower end of the market.

Vehicle equipped with e-tags will be allowed to pass through the plazas at 40km/h – a boom will stop transgressors. Any particular lane with a transgressor in it will be closed for following traffic by an overhead lane closure signal. The e-tag will be distributed at a nominal cost for which a toll account must be opened. Co-operation with the mobile phone operators can be pursued in this regard.

The pay-as-you-go system will require stop and go conditions. The mobile phone "pay-as-you-go" (PAYG) system has proven to be very successful in Lagos. The PAYG cards have resulted in the establishment of a successful network of both wholesale outlets and thousands of retail opportunities as vendors are selling the PAYG cards in the streets. The anticipated PAYG tolling card system can potentially use the same system to distribute these cards near the toll plazas.

All the enforcement will however be done "before-the-event" – i.e. no vehicle will be allowed to pass through a toll plaza without paying first.

4.4 DESIGN OF TOLL PLAZAS

4.4.1 NUMBER OF TOLL LANES

The extent of the toll plazas (sizing) were determined by using queuing theory based on the following measure of performance (MOE):

- ⇨ Average waiting time for ETC gates of 10 seconds;
- ⇨ Average waiting time for Manual tandem gates of 30 seconds.

It can furthermore be expected that the peaking characteristics (k-factor) of roads will change over time with increasing traffic volumes, and that the utilization of ETC gates will increase given the benefits that will be illustrated in practice. Table 4-1 shows these assumptions.

Table 4-1: Assumptions on Parameters that changes over time, i.e. ETC utilization

	Period 1 2007 to 2012	Period 2 2013 to 2022	Period 3 2023 to 2037
K- Factor	10%	9%	8%
% ETC	30.0%	40.0%	50.0%
% ECT Violation	1.5%	1.5%	1.5%
% Tandem	68.5%	58.5%	48.5%

The capacity (maximum throughput) of the various lane types or situations were as followed:

- ⇨ ETC lane 600 vehicles/hour
- ⇨ ETC lane with violation 120 vehicles/hour
- ⇨ Manual tandem lane 410 vehicles/hour

Studies done in the USA have shown that the throughput of a typical tandem lane is 1.5 times the throughput of a manual lane. Since the capacity of a manual lane in RSA is typically 275 vehicles per hour, it follows that the throughput of a tandem lane can be about 410 vehicles per hour.

By adopting, the assumptions stated above, and by using queuing theory, the required number of ETC and Manual toll lanes could be calculated as shown in Table 4-2.

Table 4-2: Required Number of Lanes versus AADT Toll Traffic Demand

AADT PER DIREC-TION	Period 1 – 2007 to 2012			Period 2 – 2013 to 2022			Period 3 – 2023 to 2037		
	NUMBER OF LANES			NUMBER OF LANES			NUMBER OF LANES		
	ETC	Manual	Total	ETC	Manual	Total	ETC	Manual	Total
1,000	1	1	2	1	1	2	1	1	2
2,000	1	1	2	1	1	2	1	1	2
3,000	1	1	2	2	1	3	2	1	3
4,000	2	1	3	2	2	4	2	1	3
5,000	2	1	3	2	2	4	2	2	4
6,000	2	2	4	2	2	4	2	2	4
7,000	2	2	4	2	2	4	2	2	4
8,000	2	2	4	2	2	4	2	2	4
9,000	2	2	4	2	2	4	2	2	4
10,000	2	2	4	2	2	4	2	2	4
11,000	2	3	5	2	3	5	2	2	4
12,000	2	3	5	2	3	5	2	2	4
13,000	2	3	5	2	3	5	2	2	4
14,000	2	3	5	2	3	5	3	3	6
15,000	2	3	5	3	3	6	3	3	6
16,000	2	3	5	3	3	6	3	3	6
17,000	3	4	7	3	3	6	3	3	6
18,000	3	4	7	3	4	7	3	3	6
19,000	3	4	7	3	4	7	3	3	6
20,000	3	4	7	3	4	7	3	3	6

AADT PER DIREC-TION	Period 1 – 2007 to 2012 NUMBER OF LANES			Period 2 – 2013 to 2022 NUMBER OF LANES			Period 3 – 2023 to 2037 NUMBER OF LANES		
	ETC	Manual	Total	ETC	Manual	Total	ETC	Manual	Total
21,000	3	4	7	3	4	7	3	3	6
22,000	3	4	7	3	4	7	3	3	6
23,000	3	5	8	3	4	7	3	3	6
24,000	3	5	8	3	4	7	3	3	6
25,000	3	5	8	3	4	7	3	4	7
26,000	3	5	8	3	5	8	4	4	8
27,000	3	5	8	3	5	8	4	4	8
28,000	3	5	8	4	5	9	4	4	8
29,000	3	6	9	4	5	9	4	4	8
30,000	3	6	9	4	5	9	4	4	8
31,000	3	6	9	4	5	9	4	4	8
32,000	3	6	9	4	5	9	4	4	8
33,000	4	6	10	4	5	9	4	4	8
34,000	4	6	10	4	6	10	4	4	8
35,000	4	7	11	4	6	10	4	5	9
36,000	4	7	11	4	6	10	4	5	9
37,000	4	7	11	4	6	10	4	5	9
38,000	4	7	11	4	6	10	4	5	9
39,000	4	7	11	4	6	10	5	5	10
40,000	4	7	11	4	6	10	5	5	10
41,000	4	8	12	4	7	11	5	5	10
42,000	4	8	12	4	7	11	5	5	10
43,000	4	8	12	5	7	12	5	5	10
44,000	4	8	12	5	7	12	5	5	10
45,000	4	8	12	5	7	12	5	6	11
46,000	4	8	12	5	7	12	5	6	11
47,000	4	9	13	5	7	12	5	6	11
48,000	4	9	13	5	7	12	5	6	11
49,000	4	9	13	5	8	13	5	6	11
50,000	5	9	14	5	8	13	5	6	11
51,000	5	9	14	5	8	13	5	6	11
52,000	5	9	14	5	8	13	5	6	11
53,000	5	10	15	5	8	13	6	6	12
54,000	5	10	15	5	8	13	6	6	12
55,000	5	10	15	5	8	13	6	6	12
56,000	5	10	15	5	8	13	6	7	13
57,000	5	10	15	5	9	14	6	7	13
58,000	5	10	15	6	9	15	6	7	13

AADT PER DIREC-TION	Period 1 – 2007 to 2012			Period 2 – 2013 to 2022			Period 3 – 2023 to 2037		
	NUMBER OF LANES			NUMBER OF LANES			NUMBER OF LANES		
	ETC	Manual	Total	ETC	Manual	Total	ETC	Manual	Total
59,000	5	11	16	6	9	15	6	7	13
60,000	5	11	16	6	9	15	6	7	13
61,000	5	11	16	6	9	15	6	7	13
62,000	5	11	16	6	9	15	6	7	13
63,000	5	11	16	6	9	15	6	7	13
64,000	5	11	16	6	10	16	6	7	13
65,000	5	12	17	6	10	16	6	7	13
66,000	5	12	17	6	10	16	7	8	15
67,000	5	12	17	6	10	16	7	8	15
68,000	6	12	18	6	10	16	7	8	15
69,000	6	12	18	6	10	16	7	8	15
70,000	6	12	18	6	10	16	7	8	15
71,000	6	13	19	6	10	16	7	8	15
72,000	6	13	19	6	11	17	7	8	15
73,000	6	13	19	7	11	18	7	8	15
74,000	6	13	19	7	11	18	7	8	15
75,000	6	13	19	7	11	18	7	8	15
76,000	6	13	19	7	11	18	7	8	15
77,000	6	14	20	7	11	18	7	9	16
78,000	6	14	20	7	11	18	7	9	16
79,000	6	14	20	7	11	18	7	9	16
80,000	6	14	20	7	12	19	8	9	17
81,000	6	14	20	7	12	19	8	9	17
82,000	6	14	20	7	12	19	8	9	17
83,000	6	15	21	7	12	19	8	9	17
84,000	6	15	21	7	12	19	8	9	17
85,000	7	15	22	7	12	19	8	9	17
86,000	7	15	22	7	12	19	8	9	17
87,000	7	15	22	7	12	19	8	10	18
88,000	7	15	22	8	13	21	8	10	18
89,000	7	16	23	8	13	21	8	10	18
90,000	7	16	23	8	13	21	8	10	18

The use of reversible lanes, although economical, was not taken into account since their application is difficult with ETC operations and the use of tandem lanes. The typical directional split of traffic during peak periods (40:60) also did not favour the use of reversible lanes.

4.4.2 NUMBER OF TOLL LANES: OPEBI-MENDE LINK ROAD

The expected number of toll lanes that will be required on the Opebi-Mende Link Road is shown in Table 4-3.

Table 4-3: Opebi-Mende Link Road: Expected Number of Toll Lanes Required (Realistic Scenario)

Year	Plaza	Number of lanes required		
		Tandem Manual lanes	ETC lanes	Total lanes
2007	Mainline Plaza	4	4	8
2012		6	4	10
2022		10	6	16
2037		10	10	20
2007	Ramp Plaza 1	2	2	4
2012		2	2	4
2022		2	2	4
2037		2	2	4
2007	Ramp Plaza 2	1	1	2
2012		1	1	2
2022		2	2	4
2037		2	2	4

4.4.3 NUMBER OF TOLL LANES: LEKKI CORRIDOR AND LEKKI CORRIDOR WITH SOUTHERN BYPASS

The expected number of toll lanes that will be required in the Lekki Corridor and the Lekki Corridor with the Southern Bypass respectively is shown in Table 4-4:

Table 4-4: Lekki Corridor and Lekki Corridor with Southern Bypass: Expected Number of Toll Lanes Required (Realistic Scenario)

Year	Plaza	Number of lanes required	
		Lekki Corridor	Lekki Corridor with Southern Bypass
2007	Epe Toll Plaza 1 (Maroko)	14	16
2012		18	16
2022		18	20

Year	Plaza	Number of lanes required	
		Lekki Corridor	Lekki Corridor with Southern Bypass
2037		22	28
2007	Coastal Toll Plaza 1 (Kuramo) / Ramp Plaza	10	10
2012		14	16
2022		22	26
2037		34	42
2007	Epe Toll Plaza 2 (Chevron)	14	14
2012		16	16
2022		18	22
2037		22	28
2007	Coastal Toll Plaza 2 (Chevron)	4	4
2012		4	4
2022		8	10
2037		16	22
2007	Epe Toll Plaza 3 (4th Mainland Bridge)	NA	NA
2012		NA	NA
2022		10	10
2037		12	14
2007	Coastal Toll Plaza 3 (4th Mainland Bridge)	NA	NA
2012		NA	NA
2022		8	8
2037		12	16
2007	Ozumba Mbadiwe Ramp Plaza	NA	14
2012			16
2022			26
2037			44
2007	Akin Adesola Ramp Plaza	NA	4
2012			8
2022			14
2037			26
2007	Coastal Kuramo Mainline Plaza	NA	4
2012			10
2022			18
2037			30

4.5 LOCATION AND NUMBER OF TOLL PLAZAS

4.5.1 OPEBI-MENDE LINK ROAD

One mainline plaza is planned on Opebi-Mende Road (toll for 3.685km) east of Ikorodu Road and two ramp plazas (from south to west and from west to south movements) between Ikorodu Road and Opebi Road (toll for 0.685km).

No distinction (same toll rate) will be made between traffic travelling the full distance from Opebi to 3Rd Axial Road (3.685 km) and traffic entering/exiting at Ikorodu Road and travelling only 3.000 km on the toll road.

The proposed toll strategy is simple and reasonably fair.

4.5.2 LEKKI CORRIDOR

Both the existing Epe Expressway and the new Coastal Road will be tolled in the Lekki Corridor. Although no alternative high-capacity “free” east-west routes are thus available, some townships will allow the bypassing of toll plazas through their internal local streets. The traffic volumes that can be accommodated in this way are however low and will not pose a threat to the financial viability of the project.

This approach has the benefit that the traffic-tolling base is large which ensures low toll tariffs. A small suppression in traffic is nevertheless expected.

The total length of the corridor for the purposes of this concession is about 50 km. Improvements will be made on the existing Epe Expressway and a new Coastal Freeway will be constructed over this full distance (50 km) during the life of the concession. The traffic volumes furthermore increase rapidly closer to Victoria/Lagos Islands. This situation is expected to continue throughout the life of the concession.

It was consequently decided to plan six mainline plazas in the Lekki Corridor of which four will be provided initially and two will be added during the life of the concession. The initial four plazas (toll for 10km each) will be constructed on Maroko Road and east of the Chevron Circle on Epe Expressway, and at the same parallel positions on the new Coastal Road. The two additional plazas (toll for 10km each) will be constructed east of the 4th Mainland Bridge Link in the future.

More information on these plazas is shown in Table 4-5. The toll length for Toll Plaza 3 was assumed 10 km although the actual length will be about 25 km. This was done to improve the equitability – the majority of trips, especially initially, will have an origin or destination closer to the western end of this section and will thus be using this section for a much shorter distance than the actual length.

Table 4-5: Planned Toll Plazas in Lekki Corridor

NAME		LOCATION	CHAINAGE (0km at Falomo Bridge)	SECTION LENGTH	ASSUMED TOLL LENGTH	TIME OF CON-STRUC-TION
Toll Plaza 1	Epe Maroko Plaza	West of the Admiralty Link Junction	Km ±3	10.0 km	10 km	Initially
	Coastal Kuramo Waters					
Toll Plaza 2	Epe Chevron	East of the Chevron Circle	Km ±14	12.6 km	10 km	Initially
	Coastal Chevron					
Toll Plaza 3	Epe 4th Mainland	East of the 4th Mainland Link Junction	Km ±24	24.9 km	10 km	After year 10 of concession
	Coastal 4th Mainland					

Although fewer plazas will result in fewer stops, it will be more inequitable since higher tariffs will be paid by some motorists who are using these sections over shorter distances. It should furthermore be noted that not all motorists are using all the toll sections. Section 6.8.3 shows the utilization of the number of toll plazas (calculated with the traffic model). Table 4-6 shows that the weighted average utilization of plazas (number of plazas used by every motorist) is expected to increase from 1.9 to 2.2 plazas during the life of the concession:

Table 4-6: Summary of Utilization of Plazas

TOLL PLAZA	LOCATION	AVERAGE NUMBER OF PLAZAS USED IN 2007	% OF TRAFFIC AS % OF TOTAL TRAFFIC THROUGH ALL THREE PLAZAS IN 2007
Toll Plaza 1	West of Admiralty	1.6	56%
Toll Plaza 2	East of Chevron Circle Junction	2.1	31%
Toll Plaza 3	East of 4th Mainland Link Junction	2.5	13%
YEAR		**WEIGHTED AVERAGE NUMBER OF PLAZAS USED BY ALL MOTORISTS**	
2007		1.9	
2012		2.0	
2022		2.1	
2037		2.2	

4.5.3 LEKKI CORRIDOR WITH THE SOUTHERN BYPASS

The Southern Bypass entails the construction of a new freeway along the western and southern shores of Victoria Island on the current alignment of Ahmadu Bello Road. The length of this freeway is approximately 3.375 km, which includes the construction of new directionals to link the eastern Ring Road on Lagos Island directly with the new Southern Bypass. Ramps will be provided to link the new Southern Bypass with Ahmadu Bello Road at Ozumba Mbadiwe Road, and at Akin Adesola Road. The new Coastal Freeway will form an extension of the Southern Bypass.

The toll strategy for the Lekki Corridor with the Southern Bypass is similar to that of the Lekki Corridor without the Southern Bypass with the following additions:

- ⇨ Ramp Plazas on Southern Bypass at Ozumba Mbadiwe Road;
- ⇨ Ramp Plazas on Southern Bypass at Akin Adesola Road; and
- ⇨ Kuramo Mainline Plaza on the new Coastal Freeway.

The users of the Southern Bypass (full length of 3.375 km) will be tolled separately from the motorists that enter / exit the Coastal Freeway at Akin Adesola Road (this is accomplished by using the frontage roads for the motorists entering / exiting at Akin Adesola Road). The users of the Southern Bypass will thus pay toll for 13.375 km at the Kuramo Mainline Plaza while the motorists that enter the new Coastal Freeway at Akin Adesola Road (at the ramp plazas on the frontage roads) will pay only for a distance of 10.000 km

More information on these plazas is shown in Table 4-7.

Table 4-7: Planned Toll Plazas on Southern Bypass

NAME		LOCATION	SECTION LENGTH	ASSUMED TOLL LENGTH
Toll Plaza 1	Ozumba Mbadiwe Ramp Plaza	On ramps from Southern Bypass to Ozumba Mbadiwe Road	0.825 km	0.825 km
Toll Plaza 2	Akin Adesola Ramp Plaza	On ramps from Southern Bypass to Akin Adesola Road	2.900 km	2.900 km
Toll Plaza 3	Kuramo Mainline Plaza	At Kuramo Mainline Plaza	13.375 km (3.375 km + 10.000 km)	13.375 km

5 TRAFFIC INVESTIGATION: OPEBI-MENDE LINK ROAD

5.1 INTRODUCTION

5.1.1 DESCRIPTION OF PROJECT

The proposed Opebi-Mende Link Road is located on the Mainland along an undeveloped, swampy area (serves as storm water drainage for a larger area), and follows an east-west alignment. The route commences in the west at the existing Opebi Link Road, crossing Ikorodu Road and joining the Third Mainland Bridge / 2Rd Axial Road to the east (Ibadan Expressway). The total length of this road is 3.685km. Figure 5-1 shows a locality plan of the area.

5.1.2 RATIONALE AND JUSTIFICATION OF PROJECT

Traffic conditions in the Mainland during most of the day are poor. The level of congestion is high and traffic speeds are low. Most of the movement on the Mainland is in a north-south direction between the Mainland and the Islands. There are currently several north-south high capacity roads/freeways such as Agege Motor Road, Ikorodu road, and the Third Mainland Bridge with very few continuous east-west routes.

The planned Opebi-Mende Link Road will serve as a collector-distributor road for north-south traffic. The construction of this missing east-west link in the network will collect and distribute traffic more efficiently in a north-south direction.

5.1.3 APPROACH AND METHODOLOGY

This traffic study for the proposed Opebi-Mende Link Road has as its goal to determine the following items in order to investigate the feasibility of operating a toll road on this section:

⇨ The expected traffic flow for different network alternatives; and

⇨ The effect of toll tariffs on traffic flow and thus the optimum toll tariffs, during the concession period.

Figure 5-1: Study Area and Locality Plan

[Insert picture]

In order to achieve this goal, the study was structured according to the following tasks:

- ⇨ Describing the network
- ⇨ Investigating land use planning and future growth in the study area
- ⇨ Conducting traffic surveys
- ⇨ Identifying existing traffic characteristics
- ⇨ Conducting and analysing stated preference surveys
- ⇨ Design a toll strategy
- ⇨ Traffic modelling
- ⇨ Modelling of road user benefits
- ⇨ Determining expected future traffic
- ⇨ Performing capacity and operational analysis

5.2 NETWORK DESCRIPTION

5.2.1 EXISTING ROAD NETWORK

The road network in the Mainland area consists of a few high order arterials and many low order collector roads. The arterials include the following roads:

- ⇨ Ibadan Expressway (Third Mainland Bridge)
- ⇨ Oworonsoki Expressway
- ⇨ Ikorodu Road
- ⇨ Oregun Road
- ⇨ Opebi Road
- ⇨ Bank Anthony Road
- ⇨ Agege Road
- ⇨ Obafemi Awolowo Road

The roads within the study are of poor quality and have many serious shortcomings based on generally accepted road standards. A backlog in maintenance has also left its mark on the road network and in some areas; the physical condition of roads imparts a heavy toll on traffic flow. The absence of road markings and the minimal use of road signs also have a detrimental effect on the traffic operations of the local road network. The greatest contributor to poor road conditions, however, is the high level of road friction caused by trading activities adjacent to some of the major arterials. In most cases, informal stalls and sales stands are placed right at the edge of roads to obtain access to passing motorists. This is especially true along the southern stretches of Agege and Oregun Roads. Another cause for concern is the numerous individual informal traders patrolling the major intersections. The presence of these traders decreases safety and hampers traffic flow on the approaches.

The existing traffic demand in the study area can be described by means of appropriate north-south and east-west screen lines, as indicated in Figure 5-2. It is clear that there is a strong east-west traffic movement in the study area (approximately 100,000 vehicles per day). The existing traffic demand in terms of ADT and peak hours is described in Table 5-1:

Table 5-1: Existing Traffic Demand

Direction	ADT	Peak hour
Northbound	79,074	18:00 to 19:00
Southbound	81,504	09:00 to 10:00
Eastbound	97,438	10:00 to 11:00
Westbound	103,763	17:00 to 18:00

Five market segments were identified for use in the analyses, given that the traffic and road user characteristics of various vehicle types and trip purposes are different, namely:

- ⇨ Market segment 1: Light vehicles, work to home (commuter) trips
- ⇨ Market segment 2: Light vehicles, business trips
- ⇨ Market segment 3: Light vehicle, all other trip purposes
- ⇨ Market segment 4: Bus and taxi trips
- ⇨ Market segment 5: Heavy vehicle trips

Figure 5-2: Current Screen Line Traffic

Table 5-2 summarises the current composition of the network traffic in terms of market segments, for an average day in the week.

Table 5-2: Existing Trip Purpose

Market segment	Direction	
	NB/EB	SB/WB
1	24%	21%
2	29%	31%
3	15%	14%
4	26%	27%
5	6%	7%

NB/EB is northbound or eastbound

SB/WB is southbound or westbound

The levels of service (LOS) and volume-to-capacity ratios (v/c ratio) of the roads in the project area generally indicate congestion and saturated flow conditions. The approximate current peak hour LOS and v/c ratios for the main arterials is summarised in Table 5-3. It should be noted that these are approximate values, as these indicators vary between different sections of the same road, and are influenced by the presence of trading activities along the roads.

Table 5-3: Existing LOS and V/C Ratios

Road	Current LOS	Current v/c ratio
Ibadan Expressway	D	0.85
Oworonsoki Expressway	E	1.0
Ikorodu Road	E	1.0
Oregun Road	C	0.70
Opebi Road	D	0.90
Bank Anthony Road	E	1.0
Agege Road	E	1.0
Obafemi Awolowo Road	D	0.80

5.2.2 FUTURE ROAD NETWORK

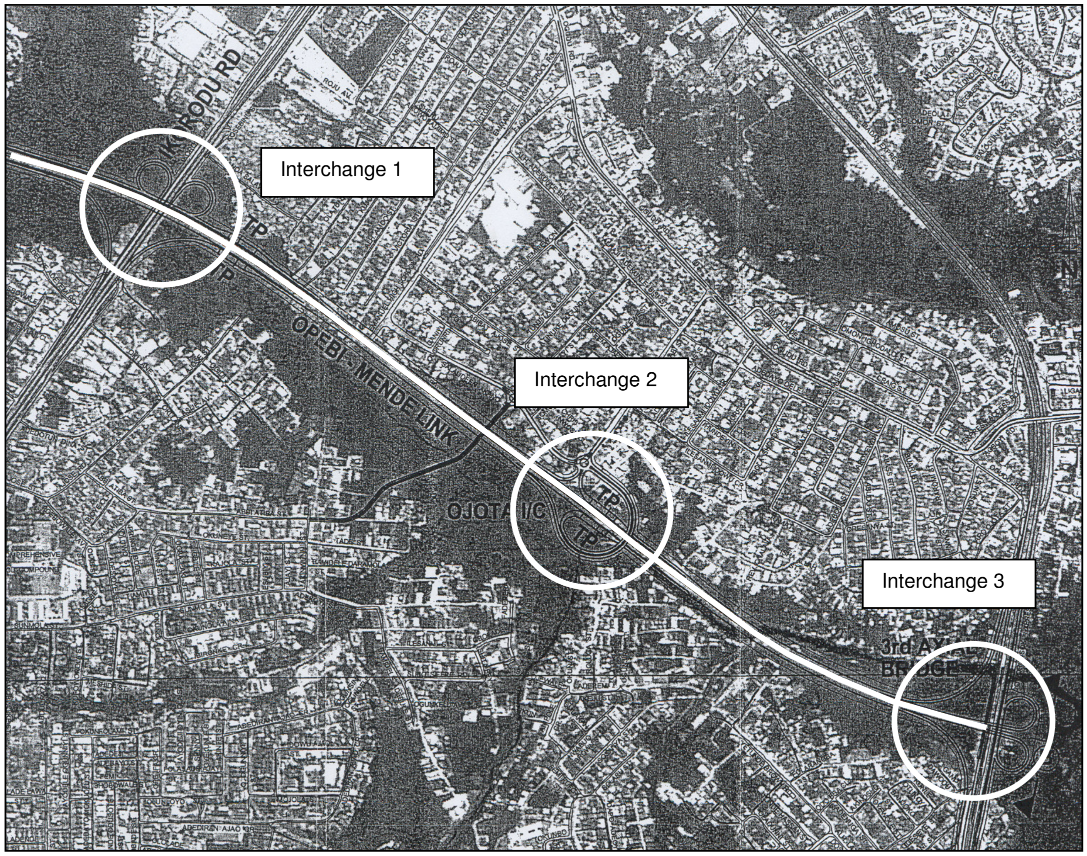
The future road network considers the scenario where the proposed Opebi-Mende Link Road is tolled. In this scenario, the following network options can be considered:

- ⇨ Network Alternative 1: The road commences in the west at Opebi Link Road and terminates with an interchange on Ikorodu Road in the east. The total length of this road is 0.685km.
- ⇨ Network Alternative 2: The road commences in the west at Opebi Link Road, proceeds east with an interchange on Ikorodu Road, and joins the 3rd Mainland Bridge with an interchange. The total length of this road is 3.685km.
- ⇨ Network Alternative 3: The same as Network Alternative 2, with the addition of an access interchange, the Ojota interchange, halfway between Ikorodo Road and Ibadan Expressway, to provide access to and from the townships just north and south of the Opebi-Mende Link Road.

Each of the three network alternatives above will require the construction of one or more of the following interchanges. These interchanges are indicated graphically in Figure 5-3.

- ⇨ Interchange 1, required for Network Alternatives 1, 2 and 3: A partial systems interchange between the Opebi-Mende Link Road and Ikorodu Road, with access only to and from the south. The option of a full interchange at this position was considered. However, the close proximity of this interchange to the Ikorodu and 3rd Mainland Bridge interchange does not allow for ramps providing access to and from the north, as this will result in substandard spacing between these two interchanges.
- ⇨ Interchange 2, required for Network Alternative 3: An access interchange, the Ojota interchange, halfway between Ikorodu Road and 3rd Mainland Bridge, to provide access to and from the townships just north of the Opebi-Mende Link Road. A bridge across the Opebi-Mende Link Road, connecting the townships south and north of the Opebi-Mende Link Road, was also proposed to allow access to and from the townships just south of the Opebi-Mende Link Road.
- ⇨ Interchange 3, required for Network Alternative 2 and 3: A cloverleaf interchange between the Opebi-Mende Link Road and the 3rd Mainland Bridge, providing full access to and from the 3rd Mainland Bridge.

Figure 5-3: Possible Interchanges Along the Opebi-Mende Link Road



5.2.3 SCENARIOS AND DESIGN YEARS (PERIODS)

For the purpose of this traffic study, it was decided to perform traffic modelling with a chosen traffic growth rate (representing the realistic scenario), and to perform a sensitivity analysis by assuming a lower and a higher traffic growth rate (representing the pessimistic and the optimistic scenarios respectively).

It was decided to assume traffic growth rates for different periods. Three periods were selected, namely:

- ⇨ Year 0 to 5 (first 5 year period)
- ⇨ Year 5 to 15 (second 10 year period)
- ⇨ Year 15 to 30 (third 15 year period)

The reason for using different growth rates for different periods is the increasing level of uncertainty as one move further into the future. For this reason, the more conservative (i.e. lower) traffic growth rates were used for the period Year 15 to 30.

Considering the factors of growth in population and GDP, as well as historical traffic data and growth rates used, it was decided to adopt the following traffic growth rates for the Mainland area in Lagos:

Table 5-4: Projected Annual Traffic Growths in Mainland Area in Lagos

Scenario	Traffic growth per time period			
	Year 0 to 5	Year 5 to 15	Year 15 to 30	Weighted Average for Concession
Pessimistic scenario	2.0%	2.0%	0.0%	1.0%
Realistic scenario	3.0%	3.0%	1.0%	2.0%
Optimistic scenario	4.0%	4.0%	2.0%	3.0%

The realistic scenario expects a 3% annual traffic growth during Year 0 to 15, and translates to a weighted average of 2% traffic growth per year over the 30-year evaluation period. This compares well with forecasts in GDP and population, and might be considered conservative when compared to historic growth rates used in previous traffic studies in the Lagos area.

5.3 TRAFFIC SURVEYS

5.3.1 DESCRIPTION OF TRAFFIC SURVEYS

The following types of surveys were conducted:

- ⇨ Origin-destination (OD) surveys
- ⇨ Manual traffic counts
- ⇨ Automated traffic counts

The origin-destination surveys were undertaken between 28 July 2004 and 21 August 2004. The surveys were conducted at 10 different stations (on or close to Ikorodu Road, Oworonski Expressway, Opebi Road, Obafemi Awolowo Way, Agege Motor Road and Mobolaji Bank Anthony Road).

The area around the proposed Opebi-Mende Road Link was divided into 10 zones, for easy interpretation of origin-destination data. The 10 different zones and the position of the various stations are indicated in Figure 5-4.

Manual traffic counts were performed at the same locations on the same dates as the origin-destination surveys. The counts were generally undertaken over a 14-hour period, from 06:00 to 20:00. The manual counts were used to calculate the sample size of the origin-destination surveys, and to extrapolate the data.

At the majority of the stations, OD surveys and traffic counts were done during the week, as well as on either a Saturday or a Sunday, except for Station S6, which was surveyed on both the Saturday and the Sunday.

An electronic count was performed on Ikorodu Road from 16 September to 5 October 2004, a total of 443 hours. The electronic count allowed investigation of the typical percentage of night traffic in the region, as well as the typical variation in traffic volumes between the different days of the week.

5.3.2 RESULTS OF TRAFFIC SURVEYS

5.3.2.1 Traffic Demand

The results of the traffic surveys (counts) are reported as follows:

- ⇨ The results of the manual traffic counts, performed from 06:00 to 20:00, for various counting periods, are indicated in Table 5-5.
- ⇨ The split between light vehicles, taxis and heavy vehicles, as per the manual traffic counts, is summarised in Table 5-6.
- ⇨ The vehicle classification shown in Table 5-7 was derived from a 10-hour count on Ikorodu Road.
- ⇨ Based on this count the expected toll classification in Table 5-8 was determined.
- ⇨ The results of the automatic vehicle count are indicated in Figure 5-5.

Figure 5-4: Zones Utilised for OD Surveys and Traffic Model and Positions of Stations

Table 5-5: Results of Manual Traffic Counts (06:00 to 20:00) per Counting Period

Period	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Weekday 1, NB/EB	16,041	24,338	28,322	11,714	6,848	28,463	0	35,825	36,328	39,866
Weekday 1, SB/WB	13,729	27,639	27,839	11,901	9,396	32,880	15,254	26,714	33,188	40,073
Weekday 2, NB/EB	15,647	23,971	32,684	11,376	7,012	26,817	0	37,315	35,339	48,733
Weekday 2, SB/WB	14,386	27,180	30,279	12,250	9,626	35,339	16,132	25,932	33,370	30,051
Saturday, NB/EB	14,495	25,766	30,026	-	-	29,399	0	33,132	35,474	-
Saturday, SB/WB	13,053	23,749	29,635	-	-	34,605	7,395	26,261	37,197	-
Sunday, NB/EB	-	-	-	7,479	5,475	26,340	-	-	-	24,952
Sunday, NB/WB	-	-	-	7,832	7,372	34,622	-	-	-	27,211

Table 5-6: Vehicle Split as per the Manual Counts

Period	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Weekday 1: Lights	74%	78%	59%	81%	57%	53%	81%	79%	62%	73%
Weekday 1: Taxis	24%	19%	31%	16%	38%	37%	15%	19%	26%	19%
Weekday 1: Heavies	2%	3%	10%	2%	5%	10%	3%	3%	11%	8%
Weekday 2: Lights	75%	79%	61%	82%	55%	52%	81%	78%	63%	71%
Weekday 2: Taxis	24%	18%	30%	16%	39%	37%	15%	19%	26%	21%
Weekday 2: Heavies	2%	2%	10%	2%	6%	10%	4%	4%	11%	8%
Saturday: Lights	75%	80%	59%	-	-	54%	90%	81%	61%	-
Saturday: Taxis	23%	17%	31%	-	-	35%	6%	16%	29%	-
Saturday: Heavies	3%	3%	10%	-	-	10%	4%	3%	10%	-

Period	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Sunday: Lights	-	-	-	86%	56%	57%	-	-	-	78%
Sunday: Taxis	-	-	-	12%	42%	31%	-	-	-	19%
Sunday: Heavies	-	-	-	2%	3%	13%	-	-	-	3%

Table 5-7: Vehicle Classification on Ikorodu Road

Direction	Car	Pick-up	Danfo (Taxi)	Molue	Bus	Rigid Trucks	Truck Trailers	Semi-Trailers	Total
Northbound	12,287	1,480	8,545	1,351	669	949	5	464	25,750
Southbound	15,347	1,458	12,125	1,115	296	1,015	1	425	31,782
Total	27,634	2,938	20,670	2,466	965	1,964	6	889	57,532
	48.0%	5.1%	35.9%	4.3%	1.7%	3.4%	0%	1.5%	100%
Direction	**Rigid**			**Truck Trailer**		**Semi-Trailer**			
	2-Axle	**3-Axle**	**4-Axle**	**5-Axle**	**6-Axle**	**3-Axle**	**4-Axle**	**5-Axle**	**6-Axle**
Northbound	833	116	0	0	5	6	368	90	0
Southbound	934	77	4	0	1	1	329	95	0
Total	1,767	193	4	0	6	7	697	185	0

Figure 5-5: Results of Automatic Vehicle Count

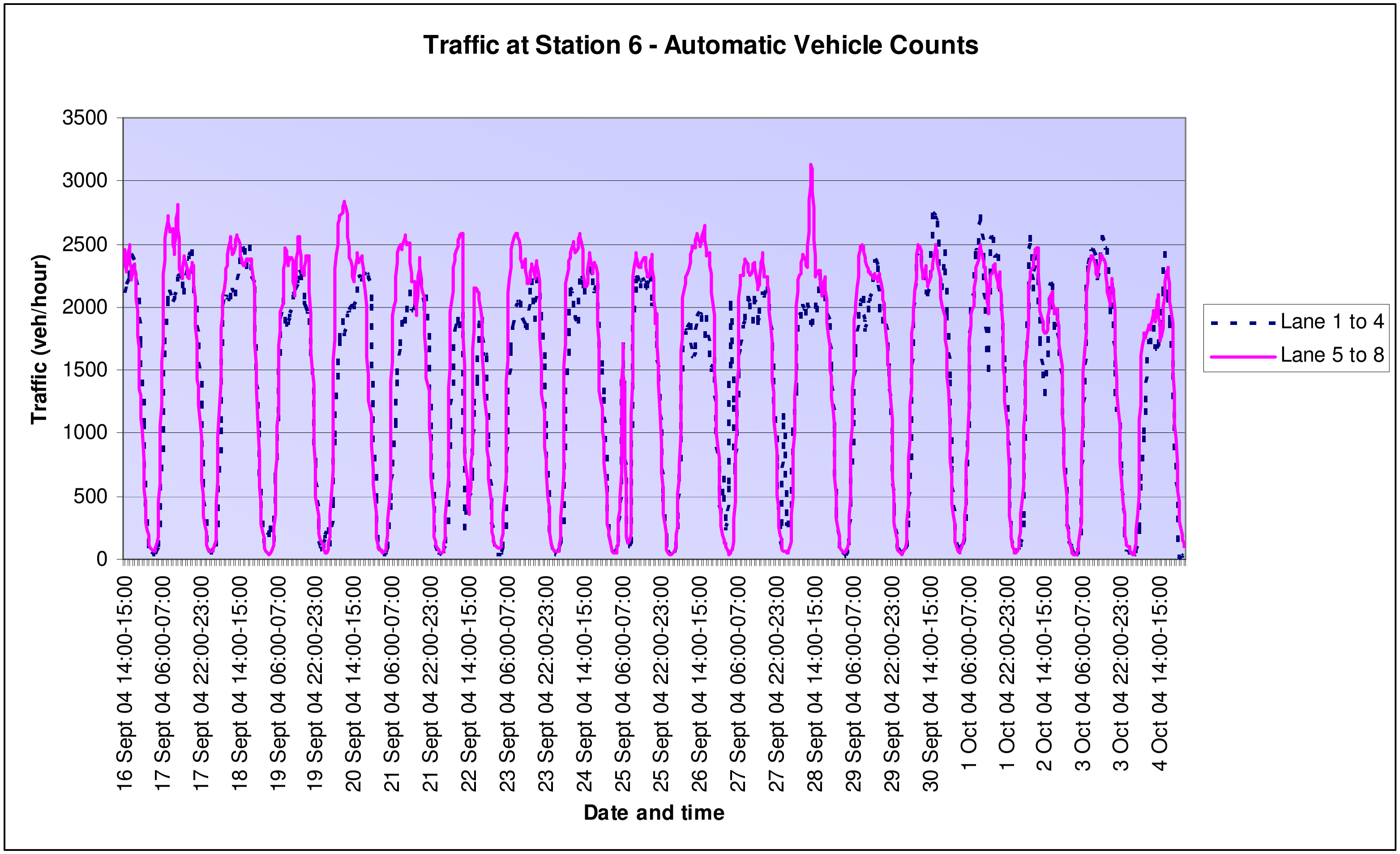


Table 5-8: Toll Classification based on Existing Vehicle Classification on Ikorodu Road

Class 1	Class 2	Class 3	Class 4	Total
51,242	5,198	901	191	57,532
89.1%	9.0%	1.6%	0.3%	100%

5.3.2.2 Origin-destination Information

About 38,600 interviews were conducted during the origin-destination surveys. This represents about 4% of all traffic counted at the same stations during the time of the surveys. The size of the sample for all stations per direction and time is indicated in Table 5-9.

Table 5-9: Sample Size of OD Surveys

Time period	Sample size (% of traffic)		
	NB/EB	SB/WB	All directions
Week AM (06:00 to 10:00)	4%	4%	4%
Week Off peak (10:00 to 15:00)	6%	7%	7%
Week PM (15:00 to 19:00)	5%	8%	7%
Saturday AM	1%	2%	1%
Saturday Off peak	3%	2%	2%
Saturday PM	3%	3%	3%
Sunday AM	3%	4%	3%
Sunday Off peak	5%	5%	5%
Sunday PM	4%	4%	4%

NB/EB is northbound/eastbound
SB/WB is southbound/westbound

The major origins and destinations, as determined from the OD surveys, are summarised in Table 5-10. Zones 3 and 10 were very prominent.

Table 5-10: Major origins and destinations

Day of week	Origin	% of all interviews	Destination	% of all interviews
Weekday NB/EB	Zone 10	33%	Zone 3	26%
Saturday NB/EB	Zone 10	30%	Zone 3	20%
Sunday NB/EB	Zone 10	36%	Zone 3	26%
Weekday SB/WB	Zone 3	19%	Zone 10	34%
Saturday SB/WB	Zone 1	23%	Zone 10	33%
Sunday SB/WB	Zone 3	18%	Zone 10	37%

NB/EB is northbound/eastbound

SB/WB is southbound/westbound

The major origin-destination pairs, as determined from the OD surveys, are summarised in Table 5-11.

Table 5-11: Major origin destination pairs

Zones	Weekday	Saturday	Sunday
3 to 10	6.7%	7.1%	7.2%
1 to 3	6.8%	6.7%	6.6%
3 to 9	7.3%	6.1%	6.3%
9 to 10	5.5%	5.1%	6.6%
4 to 10	5.8%	5.8%	5.4%
Sub-total	32.1%	30.8%	32.1%
Other combinations	67.9%	69.2%	67.9%
Total	100%	100%	100%

5.3.2.3 Other Results from Roadside Interviews

The analysis of trip purpose showed that most of the trips are business related - i.e. 60% compared to 21% commuters and 17% leisure/entertainment. The results of the trip purpose analysis is summarised in Table 5-12.

Table 5-12: Results of Trip Purpose Analysis

Trip purpose	% of all
Home to work and vice versa	21%
Business	60%
Education	2%
Shopping/leisure	17%
Total	100%

The origin-destination survey also recorded the frequency of a trip. It was found that, on average, a vehicle makes the same trip (one-way) 10 times a week. This value is higher for taxis and buses, as can be expected. Trip frequency is indicated in Table 5-13.

Table 5-13: Trip Frequency

Vehicle class	Trip frequency per trip purpose				
	Commuter	Business	Education	Shopping/ leisure	Total
Car	6	8	5	3	6
Taxi	9	23	7	5	22
Bus	6	12	7	3	10
Heavy vehicle	5	6	5	3	6
Total	6	13	6	3	10

The average travel time, as indicated by road users during the origin-destination surveys, is in the order of 35 minutes for cars, taxis and buses. This is obviously weighed heavily for the majority trip purpose namely business trips. For heavy vehicles, average travel time is slightly higher, namely 48 minutes.

The average stated trip times appeared rather low taking into account the congested travel conditions. This information was also refuted by the results of the SP surveys of 54 minutes for the average trip time on the Mainland.

Most of the road users (67%) make use of private vehicles.

5.3.2.4 Travel Time Surveys

Travel time surveys were conducted along the major roads within the study area over a period of two weeks. The travel time surveys were grouped according to certain time allocations and effort was made to ensure that there were at least three sets of travel times obtained for each link for each designated period. The periods allocated were based on travel times obtained during the week, on Saturdays or on Sundays and were designated as follow:

- ⇨ Morning peak (06:00 to 10:00)
- ⇨ Off-peak (10:00 to 15:00)
- ⇨ Afternoon peak (15:00 to 19:00).

In addition to travel time, the corresponding distances of major links were also measured to establish the average speeds on those links. A sample of the travel time surveys is provided in the form of the southbound movement along Oregun Road between Obafemi Awolowo Way and Jagal Road:

- ⇨ Morning peak travel time and speed – 00:02:03 (hh:mm:ss) @ 51.15 km/h;
- ⇨ Off-peak travel time and speed – 00:02:25 @ 43.39 km/h; and
- ⇨ Afternoon peak travel time and speed – 00:02:37 @ 44.87 km/h.

All the relevant links were measured in the same way, and this data (more than 1500 records) was used in the calibration of the traffic model. Some of the highlights of the travel time surveys were the following:

- ⇨ Very long travel times (low speeds) were experienced along Opebi Road in the northbound direction during the weekday afternoon peaks;
- ⇨ Very long travel times (low speeds) were experienced along Bank Anthony Road in both directions during all weekday periods;
- ⇨ In Obafemi Awolowo Way very long travel times (low speeds) were experienced during the afternoon peaks in mostly the eastern direction of traffic flow;
- ⇨ The southern parts of Agege Motor Road and Oregun Road displayed long travel times (low speeds) during all periods due to the presence of roadside markets and traders.

The major arterials (Oworonsoki-, Ibadan- and 3rd Mainland Bridge Expressways), with the exception of Ikorodu Road, generally displayed relatively good travel times in the absence of incidents that may cause a breakdown in traffic flow.

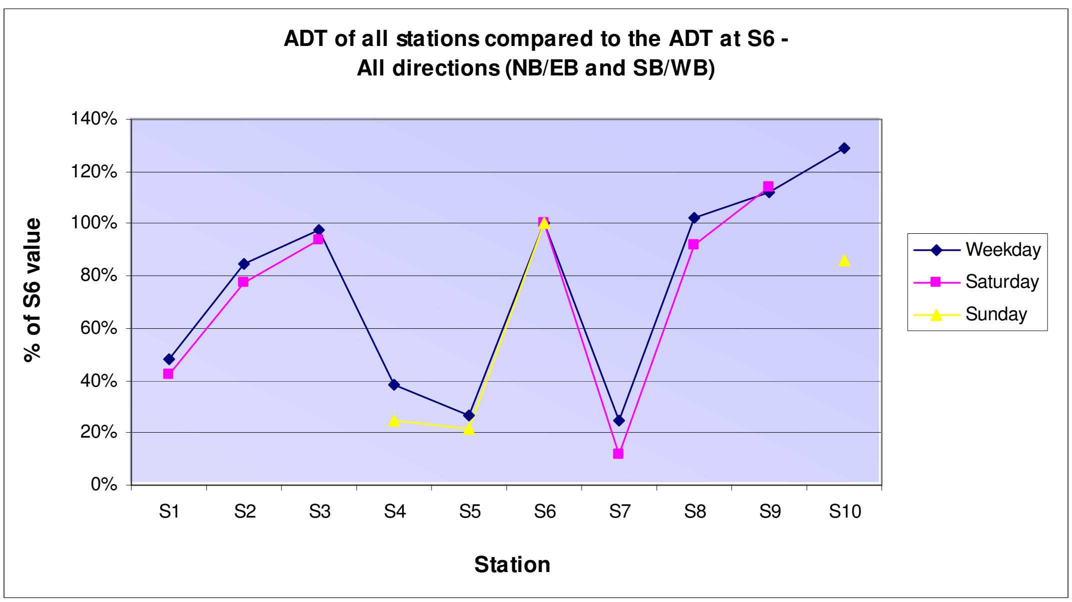
5.4 EXISTING TRAFFIC CHARACTERISTICS

5.4.1 AVERAGE ANNUAL TRAFFIC DEMAND (AADT)

The methodology followed in the feasibility study required data for both a Saturday and a Sunday. As counts were performed only on a Saturday or a Sunday at most of the stations, it was necessary to estimate values for the days without survey data. The daily traffic per station was plotted using Station S6 as a base. This is indicated in

Figure 5-6. This graph showed that daily traffic at all stations tends to follow the same pattern over weekends (Saturdays and Sundays) as during the week. E.g. during the week, S1 has about 45% of the daily traffic flow at S6. On a Saturday, this value is also in the order of 45%. Therefore, one can expect the value on a Sunday also to be in the order of 45%. This assumption was used to estimate daily traffic flow for all Saturdays and Sundays where no information was available.

Figure 5-6: ADT of all stations compared to the ADT of Station S6



The typical percentage of night traffic (i.e. traffic between 19:00 and 06:00) was calculated from the continuous electronic counts. It was found that night traffic is typically 22% of the ADT, over weekends as well as weekdays.

The electronic count also allowed calculation of a seasonal factor, as most of the manual counts were done during the school holidays, while the electronic count was done after the school holidays. In comparing the results from the manual and electronic counts however, it was found that the traffic levels were very similar, and that the seasonal factor is therefore negligible.

The estimated AADT was then calculated from the manual counts, taking into account the factors determined from the electronic counts as discussed above. The AADT at each station is summarised in Table 5-14.

5.4.2 CLASSIFICATION PER VEHICLE CLASS, TRIP PURPOSE AND MARKET SEGMENT

Vehicles were divided into classes, as different road users would have different values of time, and different vehicles would pay different toll fees and would thus demonstrate different diversion patterns. The classification of vehicles for use in the demand matrices was according to the classifications used in the Roadside interviews. Five classes of vehicles (hereafter referred to as "market segments") were determined, each representing a combination of a vehicle class and a trip purpose. The five market segments are the following:

- ⇨ Market segment 1: Light vehicles, work to home (commuter) trips
- ⇨ Market segment 2: Light vehicles, business trips
- ⇨ Market segment 3: Light vehicle, all other trip purposes
- ⇨ Market segment 4: Bus and taxi trips
- ⇨ Market segment 5: Heavy vehicle trips

Table 5-14: AADT Values at Count Stations

AADT	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Weekday NB/EB	18,640	29,014	36,704	13,962	8,224	32,660	-	43,773	43,064	52,097
Saturday NB/EB	17,092	30,699	36,077	9,907	7,431	35,383	-	39,497	42,477	33,260
Sunday NB/EB	15,133	27,428	32,157	8,753	6,563	31,527	-	35,310	37,832	29,542
Weekday SB/WB	17,142	33,356	35,321	14,428	11,549	41,248	18,323	31,620	39,908	43,085
Saturday SB/WB	15,738	29,095	36,078	9,158	9,158	41,629	8,895	31,263	45,118	33,304
Sunday SB/WB	15,633	28,797	35,790	9,108	8,908	41,138	8,639	30,854	44,430	32,792
Weekday total	35,783	62,371	72,026	28,390	19,774	73,909	18,323	75,393	82,972	95,182
Saturday total	32,830	59,794	72,155	19,065	16,589	77,013	8,895	70,760	87,595	66,564
Sunday total	30,766	56,225	67,947	17,860	15,471	72,665	8,639	66,164	82,262	62,335
AADT	**34,644**	**61,125**	**71,462**	**25,554**	**18,704**	**74,175**	**15,593**	**73,413**	**83,531**	**86,401**

5.4.3 PERIODS OF TRAFFIC FLOW

The road network in the vicinity of the proposed Opebi-Mende Link Road will experience different levels of usage (i.e. different levels of congestion) during different times of the day. The level of congestion of the network will have a significant effect on the expected traffic volumes on the proposed Opebi-Mende toll road. More vehicles will divert to the toll road during times of high congestion as their time saving using the toll road will be more during times of high congestion, and vice versa. Therefore it is necessary to identify different periods of time with regards to traffic flow, to investigate diversion for times of high congestion and times of low congestion on the network.

Typically one would find that, during the week, the highest period of congestion occurs during the morning and the afternoon, due to commuter traffic. Between the AM and PM peaks, traffic is usually lower, while traffic is much lower during the night. In Lagos in the area of the Opebi-Mende Link Road, it was however found that road usage is very high throughout the day. This is clearly demonstrated by the graphs of 15-min traffic flows for a typical station in this area (S6), in Figure 5-7 and Figure 5-8.

As no distinct peak periods could be deduced from the traffic counts, it was decided to differentiate between the following time periods:

- ⇨ AM peak (06:00 to 10:00)
- ⇨ Off peak (10:00 to 15:00)
- ⇨ PM peak (15:00 to 19:00)
- ⇨ Night period (19:00 to 06:00)

Figure 5-7: 15-min Traffic Flow During a Weekday at Station S6 for the Northbound / Eastbound Direction

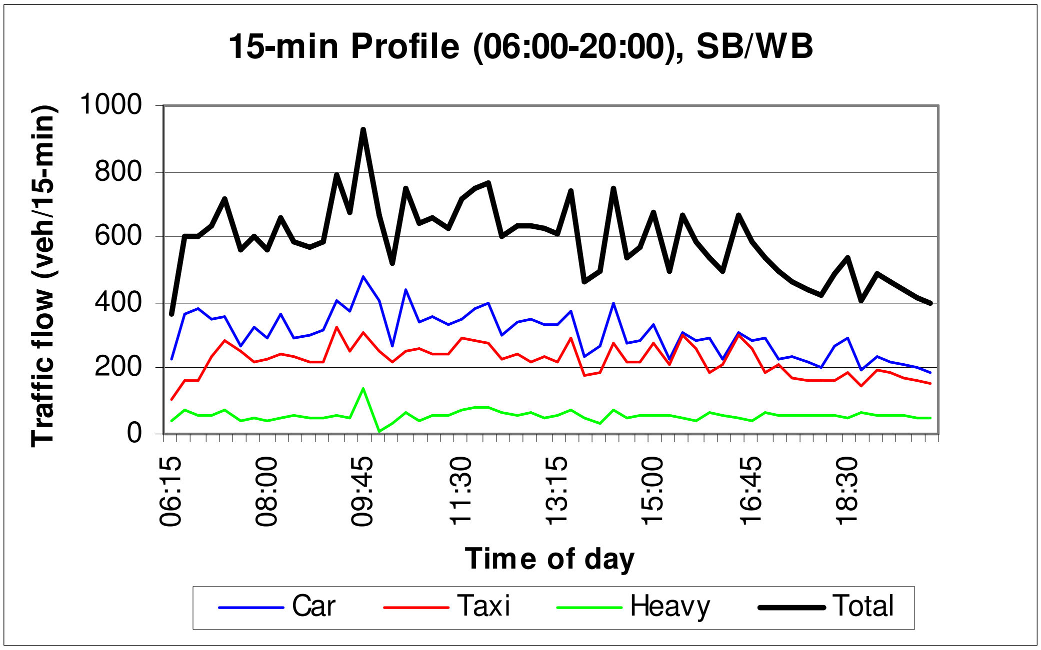
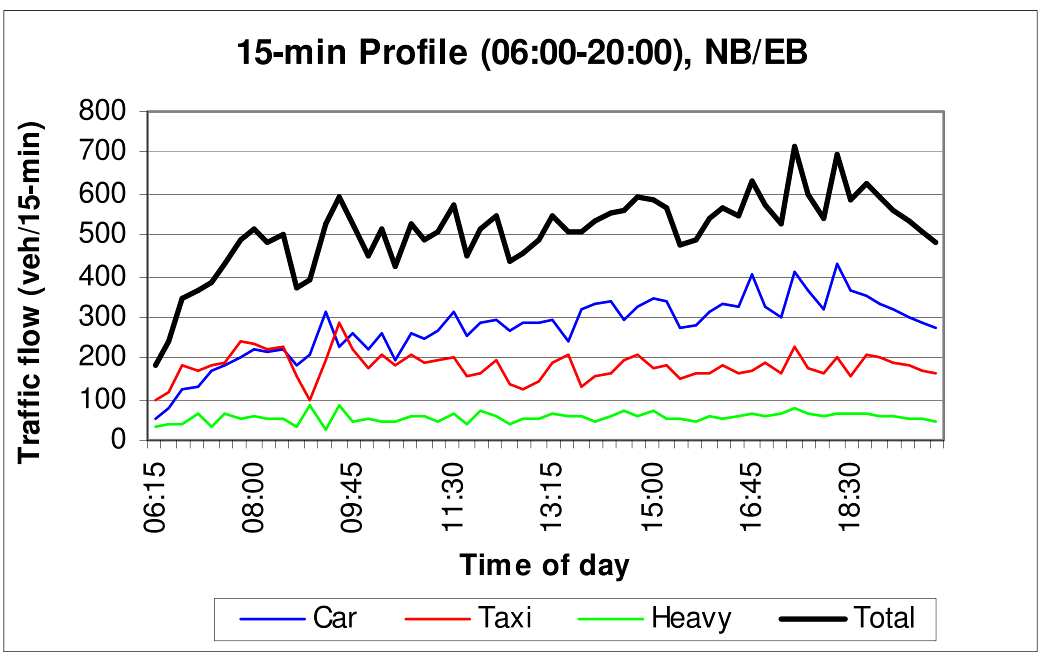


Figure 5-8: 15-min Traffic Flow During a Weekday at Station S6 for the Southbound / Westbound Direction



5.4.4 DESCRIPTION OF MARKET SEGMENTS AND ANALYSIS PERIODS

The distribution of traffic between the five market segments for the various analysis periods, are summarised in Table 5-15. It is clear from the table that market segments 1, 2 and 4 (light vehicle commuter trips, light vehicle business trips and buses / taxis respectively) represent most of the traffic. It is also clear that market segment 2 (light vehicles business trips) represents most of the traffic during the off peak period (10:00 to 15:00).

Table 5-15: Traffic Divided into Market Segments per Analysis Period

Time period	Market Segment				
	1	2	3	4	5
Weekday AM, NB/EB	28%	32%	8%	29%	4%
Weekday Off peak, NB/EB	18%	37%	13%	27%	5%
Weekday PM, NB/EB	32%	24%	12%	26%	6%
Weekday AM, SB/WB	26%	31%	6%	31%	6%
Weekday Off peak, SB/WB	15%	39%	11%	27%	8%
Weekday PM, SB/WB	28%	27%	11%	27%	7%
Saturday AM, NB/EB	13%	23%	33%	25%	6%
Saturday Off peak, NB/EB	12%	33%	22%	28%	6%
Saturday PM, NB/EB	18%	26%	23%	26%	7%
Saturday AM, SB/WB	18%	30%	23%	25%	4%
Saturday Off peak, SB/WB	13%	33%	21%	25%	9%
Saturday PM, SB/WB	19%	25%	23%	27%	6%
Sunday AM, NB/EB	13%	20%	32%	27%	8%
Sunday Off peak, NB/EB	16%	29%	21%	27%	6%
Sunday PM, NB/EB	27%	24%	19%	25%	5%
Sunday AM, NB/EB	14%	21%	30%	28%	7%
Sunday Off peak, NB/EB	12%	32%	22%	27%	7%
Sunday PM, NB/EB	22%	25%	21%	26%	7%

5.4.5 ORIGIN-DESTINATION INFORMATION PER MARKET SEGMENT

The OD-data obtained during the roadside surveys were used to determine matrices of OD pairs for the project area. These matrices are termed demand matrices. The demand matrices describe the number of vehicles, per vehicle classification, between each origin-destination pair, for different time periods of the week.

The resulting demand matrices served as input into the traffic model, to be used to calculate the distribution of trips within the network. The demand matrices per market segment, analysis period and direction of flow, is summarised in Annexure A.

5.5 TOLL STRATEGY

In investigating the feasibility of the proposed Opebi-Mende Link Road, different network options and toll tariffs should be considered in order to determine the optimum set-up of the toll road. The various scenarios tested will be discussed in this section.

5.5.1 DESIGN YEARS

The concession period and thus the lifetime of the proposed Opebi-Mende toll road was assumed to be 30 years.

It is assumed that the construction of the Opebi-Mende Link Road and the toll plazas would take two years (2005 and 2006). Thus, the base year for calculations was therefore chosen as 2007 (first year of operations).

It was decided to run the model for the base year, as well as for three future years (in accordance with the estimated future traffic growth rates), namely:

- ⇨ After 5 years of operation (2012)
- ⇨ After 15 years of operation (2022)
- ⇨ After 30 years of operation (2037)

Three distinct periods were therefore analysed namely 2007 to 2012 (5 years), 2013 to 2022 (10 years), and 2023 to 2037 (15 years).

5.5.2 NETWORK OPTIONS

The future road network considers the scenario where the proposed Opebi-Mende Link Road is tolled. In this scenario, the following network options can be considered:

- ⇨ Network Alternative 1: The road commences in the west at Opebi Link Road and terminates with an interchange on Ikorodu Road in the east. The total length of this road is 0.685km.
- ⇨ Network Alternative 2: The road commences in the west at Opebi Link Road, proceeds east with an interchange on Ikorodu Road, and joins the 3rd Mainland Bridge with an interchange. The total length of this road is 3.685km.
- ⇨ Network Alternative 3: The same as Network Alternative 2, with the addition of an access interchange, the Ojota interchange, halfway between Ikorodo Road and Ibadan Expressway, to provide access to and from the townships just north and south of the Opebi-Mende Link Road.

Each of the three network alternatives above will require the construction of one or more of the following interchanges. These interchanges are indicated graphically in Figure 5-3.

- ⇨ Interchange 1, required for Network Alternatives 1, 2 and 3: A partial systems interchange between the Opebi-Mende Link Road and Ikorodu Road, with access only to and from the south. The option of a full interchange at this position was considered. However, the close proximity of this interchange to the Ikorodu and 3rd Mainland Bridge interchange does not allow for ramps providing access to and from the north, as this will result in substandard spacing between these two interchanges.

- ⇨ Interchange 2, required for Network Alternative 3: An access interchange, the Ojota interchange, halfway between Ikorodu Road and 3rd Mainland Bridge, to provide access to and from the townships just north of the Opebi-Mende Link Road. A bridge across the Opebi-Mende Link Road, connecting the townships south and north of the Opebi-Mende Link Road, was also proposed to allow access to and from the townships just south of the Opebi-Mende Link Road.

- ⇨ Interchange 3, required for Network Alternative 2 and 3: A clover interchange between the Opebi-Mende Link Road and the 3rd Mainland Bridge, providing full access to and from the 3rd Mainland Bridge.

During the feasibility study, the above network alternatives and interchange geometries were considered. A short discussion on them is presented in the next sections.

▲ Network Alternatives

Because of the short length of the proposed Opebi-Mende Link Road, network alternatives were limited.

Since Network Alternative 1 could not serve the intended function, it was excluded from further analyses. It was also decided to locate the mainline plaza to the east of the Opebi-Mende Link Road and Ikorodu Road interchange, to make construction easier / reduce the cost of construction, and to attract higher traffic volumes.

This location of the mainline plaza, i.e. east of the Opebi-Mende Link Road and Ikorodu Road interchange, however has resulted in limited space being available for the construction of the Ojota interchange. Given that this access arrangement will be substandard, Network Alternative 3 was also excluded from further analyses.

Only Network Alternatives 2 was therefore investigated.

▲ **Interchange Geometry**

A partial systems interchange between the Opebi-Mende Link Road and Ikorodu Road, with access only to and from the south, was proposed in the pre-feasibility study. To provide access to and from the north as well is not advised from a geometric point of view, as well as from an access-mobility point of view. This is due to the close proximity of this proposed interchange to the current Ikorodu and 3rd Mainland Bridge interchange to its north, which will result in substandard spacing between these interchanges should access also be provided to and from the north at the Opebi-Mende Link Road. Therefore, the design of this interchange was kept the same as proposed in the pre-feasibility, i.e. only provide access to and from the south.

The design of the interchange between the Opebi-Mende Link Road and the 3rd Mainland Bridge, as proposed in the pre-feasibility study, was kept the same, i.e. to provide full access to and from the north and south (i.e. full access). In future, the construction of the proposed 4th Mainland Bridge may extend the Opebi-Mende Link Road in an eastern direction which may require changing this interchange into a full cloverleaf.

5.5.3 TOLL OPTIONS

The following aspects are considered under toll options:

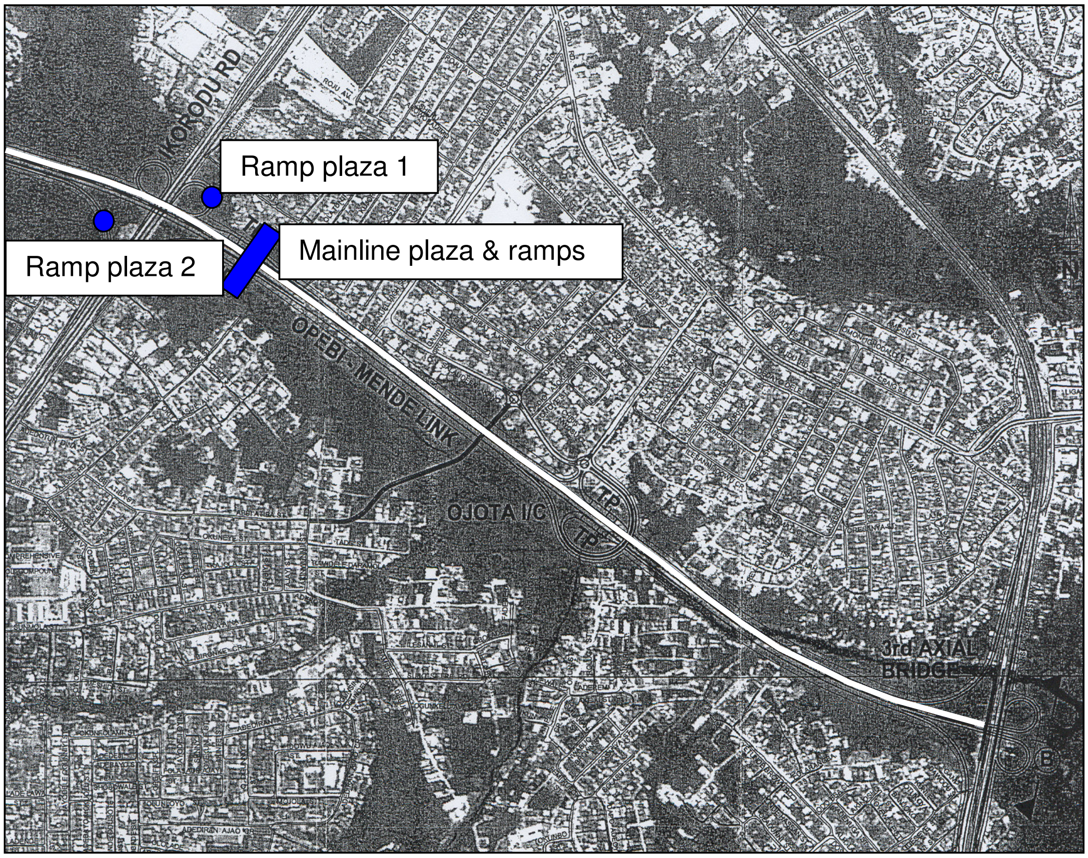
- ⇨ Toll plazas
- ⇨ Toll rates

▲ **Toll Plazas**

Based on the discussion above, it was decided to design the traffic model for one mainline plaza to the east of the Opebi-Mende Link Road and Ikorodu Road interchange with two ramp plazas, as follows (also see Figure 5-9):

- ⇨ One ramp plaza (Ramp Plaza 1) for vehicles from Ikorodu Road (northbound vehicles) and turning westbound onto the Opebi-Mende Link Road, therefore using 0.685km of the proposed toll road.
- ⇨ One ramp plaza (Ramp Plaza 2) for vehicles from from Opebi-Mende Link Road (eastbound vehicles) and turning southbound onto Ikorodu Road, therefore using 0.685km of the proposed toll road.

Figure 5-9: Proposed Toll Plazas on Opebi-Mende Toll Road



▲ **Toll rates**

Various toll rates were modelled, in order to find an optimum toll rate (the rate that maximises the revenue).

Table 5-16 and Figure 5-10 show that higher toll rates are expected to result in higher overall revenue even with the lower traffic. The optimum (turning point) is not reached in the range up to 175 Naira.

However, for practical reasons, taking into account willingness to pay and affordability, an “optimum toll rate” of Naira 100 (for Class 1 vehicles at the mainline) was selected for traffic modelling purposes, due to the sensitivity of and controversy related to the implementation of high toll tariffs.

A toll rate of Naira 100 was therefore used in the traffic model, for Class 1 vehicles for the mainline plaza. For the ramp plazas, a toll rate of Naira 20 was used for Class 1 vehicles. These lower toll rates are warranted because vehicles using the ramps will only utilise 20% of the total toll road.

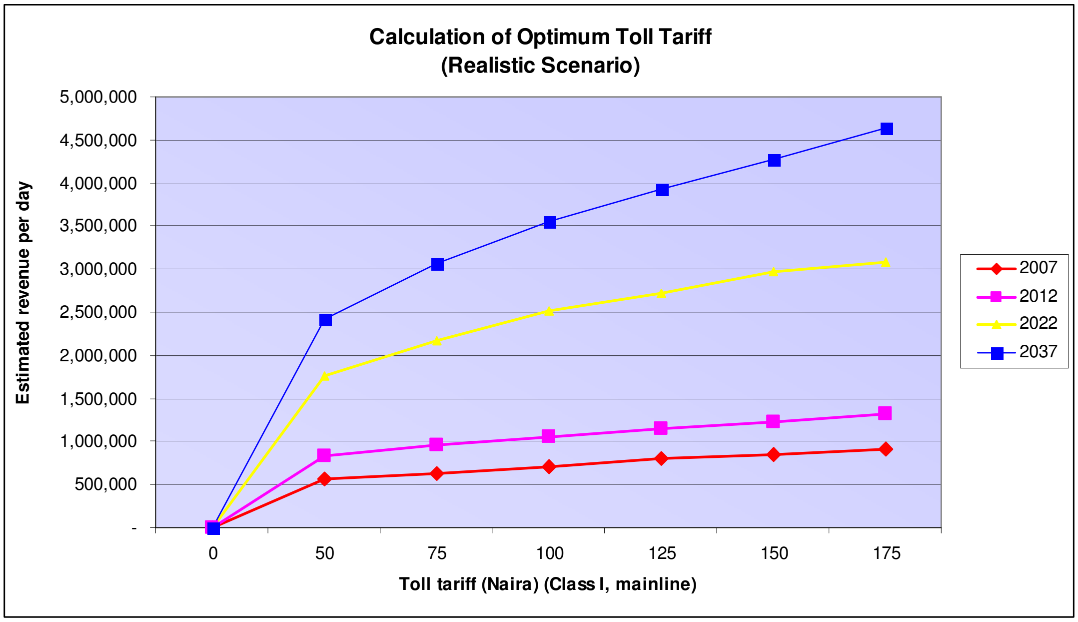
For Class 2, 3 and 4 vehicles, toll rates of respectively 2.5 times, 3 times and 4 times the rate for Class 1 vehicles were used. This is justified in Section 3.

The traffic modelling was based on a value of time (VOT) of 100 Naira per hour and 200 Naira per hour respectively. However, Section 0, motivates the use of the higher value of 200 Naira per hour.

Table 5-16: Optimum Toll Rate during the Weekday AM Peak Hour

TOLL RATE (NAIRA)	2007	2012	2022	2037
	WEEKDAY AM PEAK HOUR TOLL TRAFFIC DEMAND			
0	4,116	4,832	6,663	7,711
50	1,022	1,572	3,358	4,595
75	785	1,215	2,734	3,908
100	672	1,022	2,386	3,405
125	612	885	2,066	3,012
150	542	799	1,888	2,728
175	505	742	1,679	2,539
	WEEKDAY AM PEAK HOUR TOLL REVENUE (CONSTANT NAIRA)			
0	0	0	0	0
50	51,100	78,600	167,900	229,750
75	58,875	91,125	205,050	293,100
100	67,200	102,200	238,600	340,500
125	76,500	110,625	258,250	376,500
150	81,300	119,850	283,200	409,200
175	88,375	129,850	293,825	444,325

Figure 5-10: Calculation of Optimum Toll Tariff



5.6 TRAFFIC MODELLING

5.6.1 DESCRIPTION OF TRAFFIC MODEL

In order to assess the traffic volumes, both for the base year and in the future, as well as the impact of tolls on the attractiveness of the link road, a traffic demand model was developed.

For this purpose **ptv Visum** of the ptv Vision suite of programs was used. ptv Visum is a comprehensive state-of-the-art transportation planning software package with various models with an emphasis on integration, both for the different modes of transport as well as for the different levels of planning, from macro to micro planning. It combines all relevant aspects of private and public transport planning in one comprehensive transportation model. ptv Visum supports the following functionality among others:

- ⇨ Estimation of driver and vehicle requirements
- ⇨ Cost-benefit analysis
- ⇨ Creation of presentation graphics to illustrate different planning variants or differences between planning variants and the current state
- ⇨ Generation of partial networks with corresponding partial O-D Matrices
- ⇨ Prognosis of the impact of toll roads

- ⇨ Separate analysis of different private transport systems (car, heavy vehicle, bicycle, etc.)
- ⇨ Comparison / improvement of O-D Matrices with traffic counts
- ⇨ Easy demand matrix construction and manipulation.

VISUM is based on sophisticated component software architecture and has been developed as a PC-application for MS Windows. The integrated network model differentiates between private transport (PrT) and public transport (PuT) systems. VISUM covers an extensive scope of applications and has become the leading software for traffic simulation worldwide. More than 800 companies and institutions in over 50 countries on 5 continents rely on the solutions provided by VISUM, especially in terms of traffic network planning and traffic flow optimisations. VISUM is of German origins.

5.6.2 DESCRIPTION OF MODELLING PROCEDURE

The process of building the traffic model can be divided into the following steps:

- ⇨ Preparing demand matrices
- ⇨ Building the network
- ⇨ Calibration of the model

The demand matrices were prepared by utilising the data obtained from the manual traffic counts and the O-D surveys. The demand matrices reflected the traffic demand of the various origin-destination pairs in terms of the pre-defined market segments. The small number of survey locations relative to the very large size of the study area, as well as the large size of the designated zones, necessitated matrix correction by route projection in order to correctly calibrate the model.

The building of the network in the model was based on field observations as well as information obtained from available maps and aerial photographs. The network was built over a background projection from a map of the study area. The links within the network were based on field observations of the corresponding roads that they represent as well as calculations to determine the various link attributes such as capacity, average speed, number of lanes, etc. Furthermore, localised attributes that influence traffic operations (such as the Agege market) were also included for the sake of accuracy.

The calibration of the model was mainly based on comparisons of the traffic flow in the model with the traffic flow actually obtained from the manual traffic counts. An additional comparison was made between the modelled and actual travel times as well as the observed average speeds for the relevant links. Calibration of these parameters was mostly accomplished by the inclusion of localised conditions in the model, the accurate calculation of link capacity and matrix correction by route projection. Matrix correction by route projection is primarily applied if origin or destination total values of a zone are to be multiplied by a particular value, or a particular expected value is to be attained, which can be necessary in some circumstances if information is obtained from roadside interviews and origin-destination surveys. Matrices determined from these interviews/surveys are often just random samples and must be projected to census/population values.

5.6.3 MATRIX CALCULATIONS AND ADJUSTMENTS

The OD-data obtained during the road side surveys were divided into the various directions of flow (northbound/eastbound or southbound/westbound), market segments and periods of traffic flow, and based on this information matrices of OD pairs were prepared. The matrices were subsequently extrapolated to represent 100% of the traffic. These matrices are termed demand matrices, and serve as input into the traffic model.

The extrapolation of the matrices was done in the following way:

- ⇨ It was assumed that the information obtained during the OD surveys is representative of all traffic during that specific period of traffic flow. Therefore, the matrices prepared from the OD data were extrapolated using the total traffic per direction counted at each station for each specific period of traffic flow.

- ⇨ In cases where no OD-data was available (e.g. a Saturday or Sunday) for a specific station, assumptions had to be made to prepare matrices for this specific period of traffic flow. A comparison was made between typical traffic tendencies (based on OD-data from stations S1 to S10) for a weekday, Saturday and Sunday, for the AM peak, PM peak, off peak and night period. These trends were compared to determine periods of traffic flow, which are similar. Based on this comparison, specific traffic trends were formulated for periods where no OD-data was available. (E.g. Saturday AM peak and Sunday AM peak was found to have similar traffic tendencies in terms of origin-destination pairs and distribution between market segments. Therefore, in cases where no OD-data was available for a Saturday AM peak, the OD-distribution for the Sunday AM peak was assumed.)

Due to the lack of sufficient data for the night period, it was not possible to generate demand matrices for this period. Therefore, assumptions had to be made on the amount of traffic that would use the toll plaza during the night period. The following was taken into account:

- ⇨ The night traffic in the study area typically contributes about 20% to the total daily traffic. One can therefore expect the night traffic on the toll road to be a maximum of 20% of the daily traffic on the toll road.
- ⇨ The traffic flow on the network during most of the night will probably be very low. The network will therefore have substantial spare capacity. Most of the users are expected to avoid the toll road and use alternative routes.
- ⇨ However, the night period (19:00 to 06:00) does contain some hours where the traffic is still high, e.g. 19:00 to 21:00. Once can therefore still expect some road users to make use of the toll road during this period.

Considering the above, it was decided to assume that night traffic on the toll road would contribute 5% of total daily traffic.

The resulting demand matrices served as input into the traffic model, to be used to calculate the distribution of trips within the network.

5.6.4 DESCRIPTION OF ASSIGNMENT PROCESS

Toll modelling is representing the willingness to pay for reduction in travel time and vehicle operating cost savings. Thus for toll assignments, the criteria for choosing a path consist of time and cost.

VISUM provides four assigning assignment procedures for private transport:

- ⇨ Incremental assignment
- ⇨ Equilibrium assignment
- ⇨ Learning method
- ⇨ Tribut

The Tribut assignment procedure was applied in this study. For Tribut assignments, the criteria for choosing path p consist of time t_p and cost c_p. The objective function or the generalized path choice criterion $Crit_p$ can be formulated as follows:

$Crit_p = t_p + C_p/VT = \Sigma t_L + (\Sigma c_L)/VT$

With:

t_L : travel time on a network object L as a function of traffic volume $t_L = t(vol_L)$, L may represent a link, a node or a turning movement,

vol_L : volume of link L,

c_L : toll value for using link L, assumed to be invariant of link volume,

VT : value of time in [e.g. $/h] .

The relative saturation levels of the roads and intersections along a specific route determine travel time (t_L). In loaded networks, the link travel time and the turning time is determined by a volume delay function (or capacity restraint function). Vehicle operating costs were incorporated into these volume delay functions. The volume delay functions used in this study are described in a subsequent section.

The definition of the value of time is one of the most crucial steps. In practice, there are three ways to find the parameters: revealed preference surveys, stated preference surveys or macroeconomic calculus.

When toll is introduced into a society without revealed toll experience, usually stated preference methods are applied. In the stated preference interviews, different hypothetical situations with variation of time and cost are simulated to find the critical cost-time combination (“transfer price”), where the traveller changes his behaviour.

The project team conducted stated preference (SP) studies in Lagos. The SP surveys suggested that this “transfer price” is approximately Naira 100 per hour for all market segments. This value however was contradicted by other evidence that suggests a higher value of 200 Naira for the VOT. See Section 0.

It is a bi-criterion traffic assignment method which equally considers travel time and cost. The trip choice between different paths is modelled by defining the value of time as a random variable with a distribution of the lognormal type, thus considering that each trip has a specific willingness to pay toll for travel time reduction. This approach offers a significantly better price elasticity than mono-criterion methods where the value of time is identical for all trips.

5.6.5 DESCRIPTION OF NETWORK AND ZONE SYSTEM

5.6.5.1 General Description

The ptv Visum traffic model requires the construction of a network that represents the transport system of Lagos. This network therefore describes the spatial and temporal structure of the transport supply and consists of several network objects which include relevant data:

- ⇨ *Zones* describe areas in terms of land use and also function as the origins and destinations for trips within the study area

- ⇨ *Centroid connectors* provide the connections between the zones and the links of the network

- ⇨ *Links* provide the connections between nodes (which define the positions of stops and intersections in the network) and thus describe the rail and road infrastructure

- ⇨ *Turn penalties and restrictions* indicate if it is permissible to turn at a node/intersection and specify a time penalty relating to the required permissibility of the relevant turning movement

The network objects can be described by their attributes. The attributes are either defined by the user (such as the capacity of the links) or are calculated by the model. The network furthermore distinguishes between different transport types and this allows the user to define several transport systems as a function of the different classes of vehicles identified. The following sections provide an overview of the network objects relevant and applicable to this particular traffic simulation model of Lagos.

5.6.5.2 Zones and Centroid Connectors

For the purposes of the origin-destination survey, 10 zones were defined for the Mainland. The zones were demarcated in such a way as to simplify the interpretation of the origin-destination data. The same zones were consequently encoded into the traffic model as network objects for the sake of conformance between the traffic model and the data provided by the origin-destination survey.

The function of the centroid connectors is to provide the connections between the centre of gravity of the zones and the links. In terms of the traffic model, the traffic flow that is generated by a zone is arbitrarily set to originate and terminate at the centre of gravity of the zone. The centroid connectors consequently provide the pathways by which the traffic flows can gain access to the links. Per definition, centroid connectors cannot cross impassable obstacles (such as railway lines that provide no opportunity for vehicles to cross due to the absence of at-grade crossings or bridges) and hence no centroid connectors can traverse the creek next to which the future Opebi-Mende link will be built. Due to the large sizes of the different zones, some centroid connectors are, however, forced to traverse some of the main links in the network. Fortunately these anomalies do not impart any negative influences on the functioning of the model and can therefore be ignored. Furthermore, on the Mainland, access arrangements are informal with very little restriction as to where access is granted. This presented a problem in terms of the traffic model, as it was impossible to construct centroid connectors to all possible access points on the network. Consequently, centroid connectors were limited to the main points of access as observed during the origin-destination surveys.

Figure 5-4 illustrates the zones whilst Figure 5-11 illustrates all the centroid connectors used for the traffic model.

5.6.5.3 Links

Links describe roads or rail tracks of the transport network and provide connections between nodes on the network. A link is represented in the traffic model as a directed element with both directions of the link being independent network objects sharing the same link number. The permissible transport systems on the links can also be nominated. The attributes of a link can be defined by the user and include the following:

- ⇨ Link number
- ⇨ Start- and end-node numbers
- ⇨ Link type and length
- ⇨ Permissible transport systems
- ⇨ Link capacity
- ⇨ Free flow speed
- ⇨ Toll tariffs for the different transport systems.

The user can utilise the link types with their given set of attributes to represent similar operational conditions prevalent on different roads. A multi-lane highway link type can therefore be defined and assigned to represent the Third Mainland Bridge whilst a two-lane highway can be defined and assigned to represent Oregun Road. For this particular traffic model the different link types used with their associated attributes can be viewed in Table 5-17:

Table 5-17: Link Types and Associated Attributes

Link Type	Capacity (v/h)	Free Flow Speed (km/h)	Similar Road
Two-lane highway	1,000	100	Oregun Road
Multi-lane highway	4,000	100	Third Mainland Bridge
Multi-lane urban highway	2,000	80	Ikorodu Road
Ramps	1,000	50	Any ramps
Turnarounds	500	30	Ikorodu Underpass

Figure 5-11: Centroid Connectors Utilised for the Traffic Model

[Insert figure]

Due to inadequate data availability as well as the adverse and unorthodox operating conditions (such as the absence of road markings and unrestricted access) prevalent in Lagos, difficulties were encountered in terms of determining link capacities. The capacities of the different roads were determined in accordance with methods recommended by the Highway Capacity Manual for multi-lane highways and two-lane highways. In order to ascertain the accuracy of the values, they were compared with the manual traffic counts obtained during the origin-destination surveys. Factors that affect the capacity of a roadway and that were included in the capacity calculations include the following:

- ⇨ Peak hour factor
- ⇨ Heavy vehicles
- ⇨ Grade
- ⇨ Lane- and shoulder widths
- ⇨ Number of access points
- ⇨ Number of lanes
- ⇨ Percentage of no-passing zones
- ⇨ Driver population and
- ⇨ Basic free flow speed.

The Highway Capacity Manual provides parameters to describe these factors and include them all in its prescribed methods of calculation. Table 5-18 provides a summary of the different capacities obtained. Note that the table also includes the traffic flows observed during the manual counts.

Table 5-18: Calculated Capacities of Major Links

Road	Counting Station	Calculated Capacity (v/h)	Observed Traffic Flow (v/h)
Oba Akram	S1	495	475
Bank Anthony – W	S2	1,173	921
Agege	S3	1,995	1,004
Opebi	S4	1,107	344
Oregun	S5	1,061	346
Ikorodu	S6	1,713	1,042
Ikorodu Underpass	S7	627	506

Road	Counting Station	Calculated Capacity (v/h)	Observed Traffic Flow (v/h)
Bank Anthony – E	S8	1,273	868
Oworonsoki	S9	2,202	872
Ibadan Expressway	S10	4,155	1186
Obafemi Awolowo	N/A	1,149	N/A
Jagal	N/A	693	N/A
Ibadan Service Road	N/A	626	N/A
Adekule Faji	N/A	635	N/A
Opebi Link	N/A	974	N/A
Oregun Link	N/A	944	N/A

The discrepancies between observed flow and the calculated capacity are mostly because some of the relevant roads within the study are under-utilised. Furthermore, the observed flow was based on the traffic counts on the relevant links and does by no means display the capacity for which the roads were originally designed.

The main alternative link to the proposed Opebi-Mende toll road is the section of the Lagos – Ibadan Expressway between Ikorodu Road and the interchange where the proposed link would connect with the Expressway. Initial indications are that this section of road currently experiences a vehicle/capacity ratio (v/c-ratio) in the range of 0.85 – 0.90 for both directions. Delays along this section vary from 3 minutes to 8 minutes depending on the time of day and the direction of travel. Delays may, however, be extremely high in the event of localised incidents (such as an accident) and the associated breakdown in traffic flow.

Due to the varied schedule and route operations of the public transport systems of Lagos, no public transport route was captured in the model. This allowed all public transport vehicles access to any link in the network and permitted the application of a toll tariff to all public transport vehicles.

A total number of 397 links were defined for the traffic model. The link network can be viewed in Figure 5-12.

Figure 5-12: Visum Link Network Used for Lagos Traffic Model

5.6.5.4 Turn Penalties and Restrictions

The turn penalties utilised in the model were based on the actual areas of delay caused by external factors experienced on the road network. The most significant of these were therefore the market areas at the junctions between Ikorudu Road and Agege- and Oregun Roads. The movements in the model corresponding to traversing these areas were therefore penalised with five minutes (Oregun Road) and 30 minutes (Agege Road). Furthermore, the inefficient functioning of intersections within the study area was simulated by means of restricting the capacity of specific intersection movements in the model.

5.6.6 VOLUME DELAY FUNCTIONS AND SPEED-FLOW CURVES

Volume delay functions are applied to the links in the network to simulate the effect of congestion on the travel time of an average road user for any given road section in the model.

Modelling the time dependent flow is very important in toll modelling. As cost is not flow-dependent, it is a given model input. On the other hand, time is modelled, based on flow-dependent functions and is thus a less certain input of the assignment model. However, the quality of the forecasted volumes in toll projects depends largely on path time and related cost.

Travel time (or journey time) is determined by the relative saturation levels of the roads and intersections along the chosen route of a traveller and is the most important factor affecting route choice. In terms of the traffic model, it is the traffic volume and capacity of the links that determine the saturation of links and intersections in the network. Therefore, travel time for a chosen route between two zones in the network consists of access / egress times, travel times on links and turning times at intersections. Travel times vary and can only be determined approximately. Where conditions of free flow traffic are prevalent, however, the travel time can be more accurately determined from the link length and the free flow speed.

In terms of the traffic model, when the network is loaded, the link travel times and the turning times are determined by volume delay functions (also known as capacity restraint functions). The volume delay functions serve to define the correlation between the current traffic volume and the capacity. Three different volume delay functions are provided by ptv Visum for use in the traffic model. The eventual function of choice was the BPR function from the American Bureau of Public Roads. This BPR function is as follows:

$$t_{cur} = t_0 * \left(1 + a\left(\frac{q}{q_{max} * c}\right)^b\right)$$

Where:

t_{cur} = current travel time in loaded network (s)

t_0 = free flow travel time (s)

q = volume of a network object [car units/time interval] = sum of volumes of all private transport systems including basic volume (preloaded volume):

$$q = \sum_{i=1}^{Num\ TSys} (q_i * \text{car units}_i) + \text{basic volume}$$

q_{max} = capacity (car units/time interval)

a,b,c = user-defined parameters with a = 1.0, b = 1.4 and c= 1.0

The volume delay functions for some of the links were furthermore determined by analysing the measured travel times and the manual counts. After comparison between the observed volume delay curves and those utilised in the traffic model, it was found that the BPR functions of the model were much smoother and did not display the steep increases in travel time that the observed volume delay curves were subjected to with an increase in volume. The utilisation of the observed volume delay curves in the traffic model, in combination with inadequate data for certain links, provided travel time results that were largely inaccurate. In contrast, the utilisation of the BPR functions provided much more accurate results for travel time; hence the BPR curves were used in all scenarios.

Figure 5-13 illustrates the relevant volume delay functions.

5.6.6.1 Modelling of Vehicle Operating Costs

Only fuel costs were considered in the modelling of Vehicle Operating Costs (VOC). The following fuel consumption equation was used:

$FTS_{cars} = 0.01524V^2 – 1.7010V + 1467.6/V + 100.6$

Where:

FTS = Fuel consumption (l/1000km)

V = Speed (km/hr)

Figure 5-14 shows the relationship between fuel consumption and speed.

Figure 5-13: Relevant Volume Delay Functions (VOC Excluded)

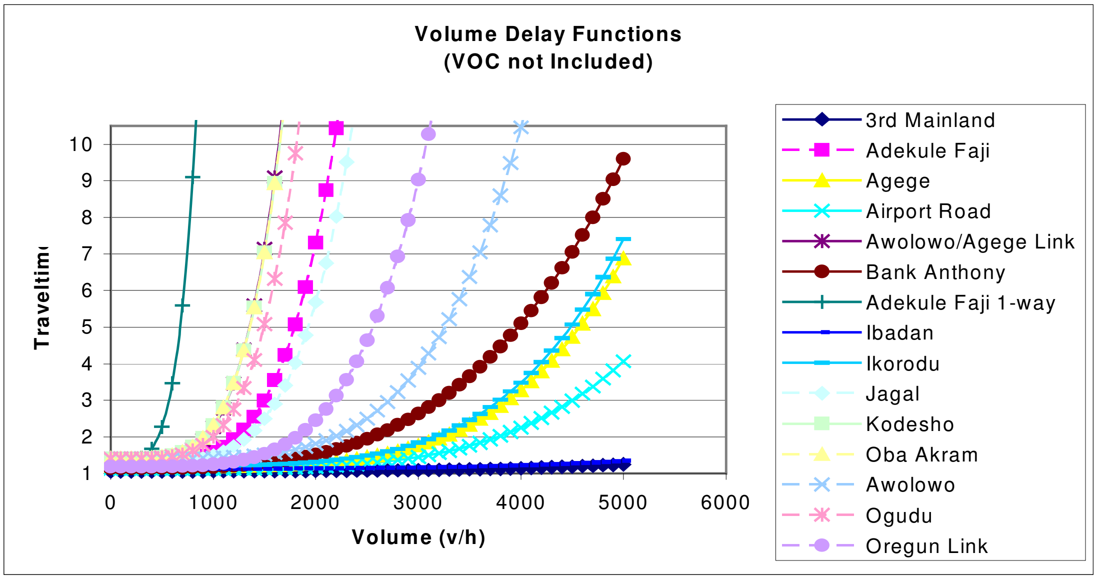
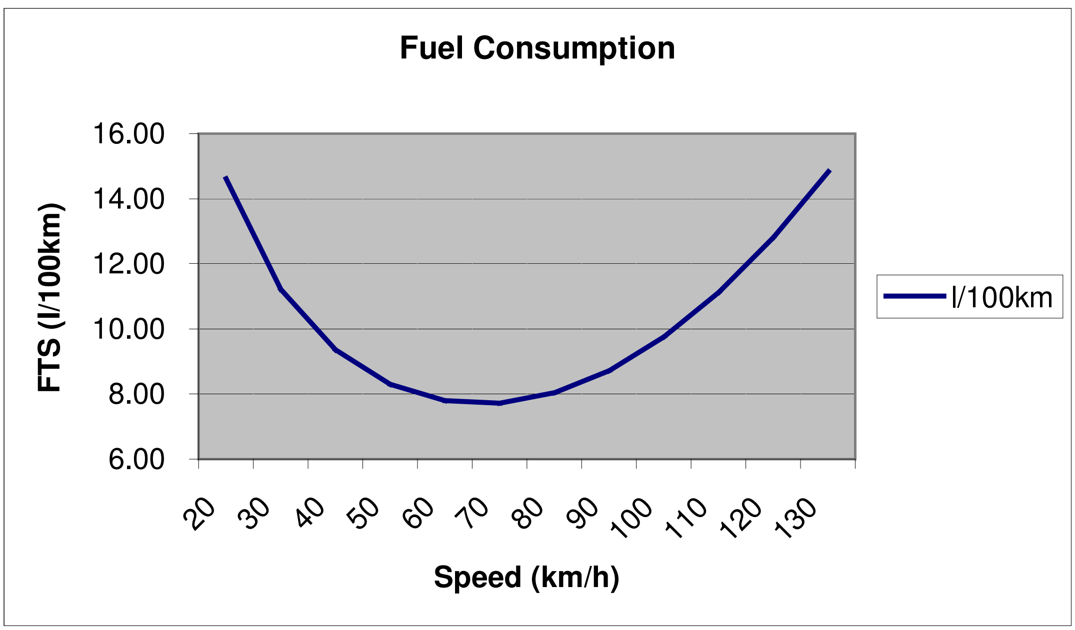
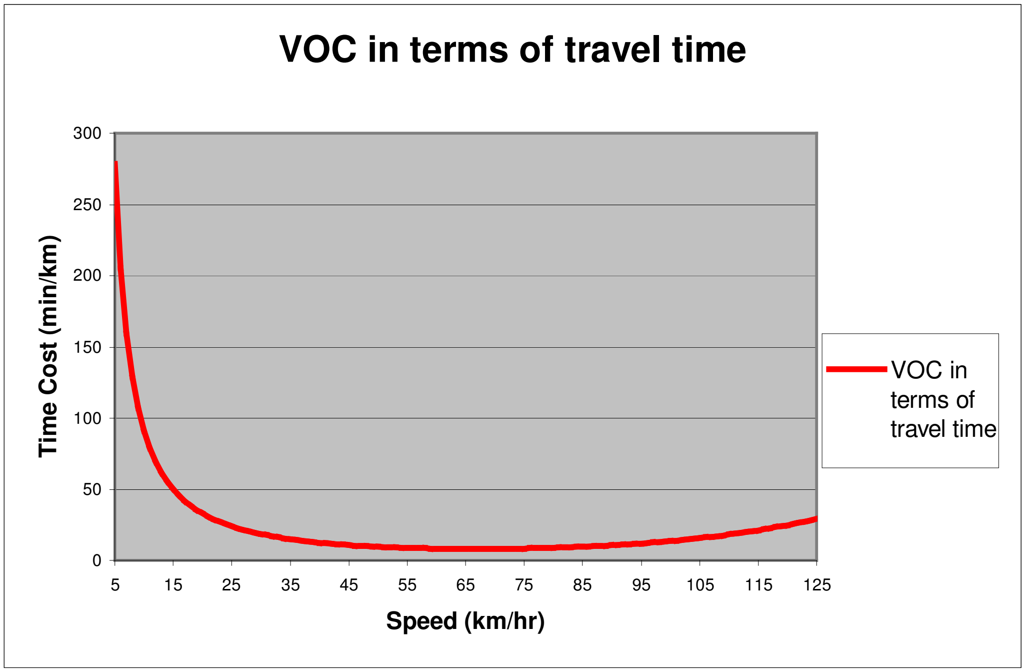


Figure 5-14: Fuel Consumption versus Speed



Vehicle operating cost was expressed as a time cost as shown in Figure 5-15.

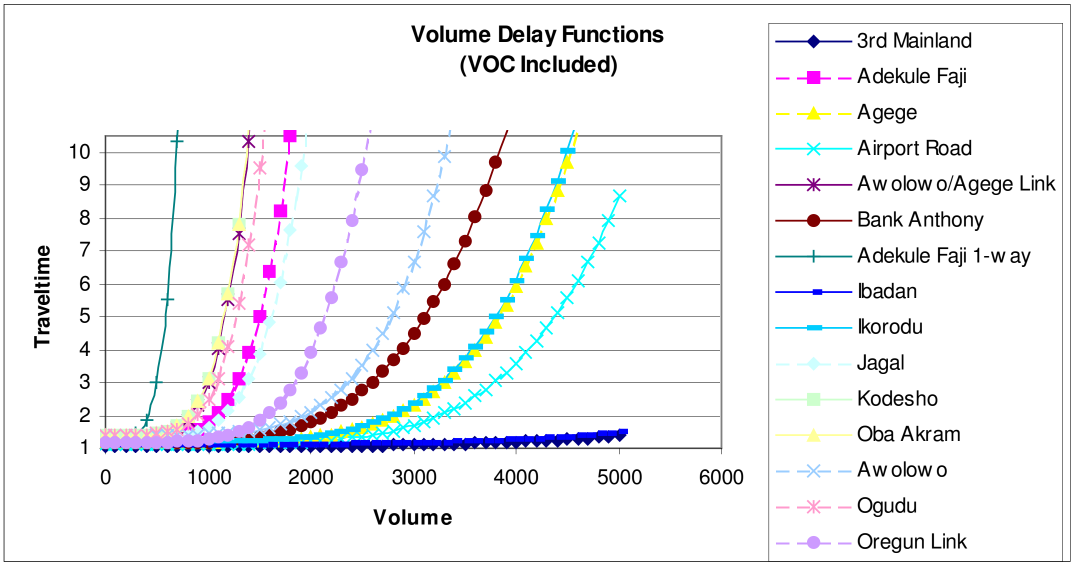
Figure 5-15: VOC in Terms of Travel Time



The vehicle operating cost was taken into consideration during the Tribut assignment by incorporating the VOC into the volume delay function. Current travel time is therefore equal to current travel time as a function of saturation PLUS vehicle operation cost expressed as a time cost.

The volume delay functions were adjusted to include this time cost. The adjusted volume delay functions are given in Figure 5-16.

Figure 5-16: Relevant Volume Delay Functions (VOC Included)



5.6.7 CALIBRATION OF MODEL

For calibrating the traffic model, the modellers referred to the results of the manual and electronic counts and the travel time surveys.

The demand matrices were determined after the analysis of the manual traffic counts and the origin-destination surveys as described in previous sections. The manual traffic counts were captured in the model to provide control data according to which the model could be calibrated. The travel time surveys provided additional control data. The different scenarios (periods) that were modelled and consequently calibrated were the following:

- ⇨ Weekday AM period (6:00 to 10:00)
- ⇨ Weekday off-peak period (10:00 to 15:00)
- ⇨ Weekday PM period (15:00 to 19:00)
- ⇨ Saturday AM period (6:00 to 10:00)
- ⇨ Saturday off-peak period (10:00 to 15:00)
- ⇨ Saturday PM period (15:00 to 19:00)
- ⇨ Sunday AM period (6:00 to 10:00)
- ⇨ Sunday off-peak period (10:00 to 15:00) and

⇨ Sunday PM period (15:00 to 19:00).

A total of nine scenarios (periods) were thus analysed for the base year. As no reliable data was available for the night period (19:00 to 6:00), the results of this scenario for the different days were determined on a basis of assuming a percentage of 5% of the daily traffic (as discussed earlier).

Due to the small sample size of the origin-destination surveys, the demand matrices had to be adjusted to correlate with the manual traffic counts at the relevant locations. This, in addition to the requirement of data output being delivered in terms of the defined market segments, necessitated the following calibration process to be followed:

⇨ Set up demand matrices (5 per scenario) for all scenarios in terms of the defined market segments

⇨ Combine segments 1, 2 and 3 to create a light vehicle matrix and combine segments 4 and 5 to create a heavy vehicle matrix

⇨ Encode manual counts into the network in terms of light- and heavy vehicles

⇨ Assign demand matrices and compare modelled travel times with travel time surveys

⇨ Conduct GEH test and assess R^2 values (a comprehensive description of these two parameters are provided later on in this section) in terms of light and heavy vehicles; this process involves the comparison of the encoded manual counts with the modelled counts at the relevant stations in the network

⇨ Assess differences in modelled and actual counts at individual counting stations in the network and adjust light vehicle matrix and heavy vehicle matrix accordingly through an iterative process

⇨ Once the GEH test yields values smaller than 10 and the R^2 values are larger than 0.8, the adjusted matrices can be used to obtain factor matrices; the factor matrices will allow the calibration parameters to be applied to the demand matrices in terms of the market segments

⇨ The demand matrices in terms of the market segments are multiplied by the relevant factor matrices to obtain new demand matrices

⇨ The new demand matrices are assigned and GEH test values and R^2 values are assessed; results are obtained in terms of the market segments.

The GEH test and the R^2 values, referred to above, are parameters used to determine the correlation between the modelled and actual values of the manual traffic counts at the different counting stations. The R^2 value returns the square of the Pearson product moment correlation coefficient through an array data points known in terms of their x- and y-coordinates. It can therefore be interpreted as the proportion of the variance in y attributable to the variance in x. The R^2 value is a dimensionless index that ranges from 0.0 to 1.0 inclusive and reflects the extent of linear relationship between two data sets. Generally a R^2 value of 0.8 or greater would indicate a very good correlation. The R^2 value is deduced, using the following equation:

$$R^2 = 1 - \frac{SSE}{SST}$$

Where:

$SSE = \sum (Y_j - \hat{Y}_j)^2$, and

$$SST = (\sum Y_j^2) - \frac{(\sum Y_j)^2}{n}$$

Although the R^2 value is useful for determining the correlation between modelled and actual values of the entire network, the GEH test provides a correlation between values of an individual link. This is particularly important in instances where only a few data points are available as is the case with this model (a maximum of 10 points are available). The GEH test is performed for all relevant links and an average value of less than 10 reflects a good fit. The GEH test is based on the following formula:

$$GEH = \sqrt{(V_2 - V_1)^2 / (0.5(V_1 + V_2))}$$

Where:

V_1 and V_2 are the modelled and actual volumes alternatively

The calibration process took into account local features on the Mainland (such as the market at the southern end of Oregun Road) that affects normal traffic in the area. In order to simulate these features, time penalties were applied to movements that are delayed by these features. Table 5-19 provides a summary of the different R^2 and GEH values that were obtained during the calibration process:

Table 5-19: R^2 and GEH Values Obtained for the Different Modelling Scenarios

Day	Time Period	Vehicle Class	R^2 Value	GEH Value
Weekday	AM	Light Vehicles	0.866	5.778
Weekday	AM	Heavy Vehicles	0.830	5.333
Weekday	Off-Peak	Light Vehicles	0.773	7.667
Weekday	Off-Peak	Heavy Vehicles	0.795	6.333
Weekday	PM	Light Vehicles	0.919	5.333
Weekday	PM	Heavy Vehicles	0.912	4.105
Weekday	Night	Light Vehicles	N/A	N/A
Weekday	Night	Heavy Vehicles	N/A	N/A
Saturday	AM	Light Vehicles	0.793	3.833
Saturday	AM	Heavy Vehicles	0.901	4.750
Saturday	Off-Peak	Light Vehicles	0.888	3.167
Saturday	Off-Peak	Heavy Vehicles	0.943	4.417
Saturday	PM	Light Vehicles	0.864	4.333
Saturday	PM	Heavy Vehicles	0.928	3.333
Saturday	Night	Light Vehicles	N/A	N/A
Saturday	Night	Heavy Vehicles	N/A	N/A
Sunday	AM	Light Vehicles	0.944	3.875
Sunday	AM	Heavy Vehicles	0.785	6.750
Sunday	Off-Peak	Light Vehicles	0.924	4.500
Sunday	Off-Peak	Heavy Vehicles	0.885	4.875
Sunday	PM	Light Vehicles	0.954	5.375
Sunday	PM	Heavy Vehicles	0.949	3.625
Sunday	Night	Light Vehicles	N/A	N/A
Sunday	Night	Heavy Vehicles	N/A	N/A
Average Values			0.881	4.855

5.7 MODELLED ROAD USER BENEFITS

The modelled road user benefits in terms of the savings in travel time in the study area is shown in Table 5-21 in terms of actual savings in minutes and in Table 5-22 in terms of relative savings in percentages. These benefits are based on weighted average time and fuel cost savings (fuel cost savings were also translated to time savings) and apply to the total traffic in the study area (see Table 5-20). The study area is defined as the total traffic in the 10 traffic zones.

Table 5-20: Toll Road Users versus Total Traffic in Study Area

	TOLL ROAD USERS	TOTAL TRAFFIC IN STUDY AREA	%
2007	10,542	3,319,960	0.32%
2012	16,881	3,928,781	0.43%
2022	41,242	5,601,174	0.74%
2037	63,467	7,337,325	0.86%

Table 5-21: Modelled Savings (weighted average) in Travel Time (minutes) with the toll road compared to without the toll road

	2007	2012	2022	2037
WEEK AM	7.6	14.4	42.7	87.6
WEEK OP	12.7	24.4	108.7	182.0
WEEK PM	13.2	24.8	161.8	271.7
DAILY	8.6	49.5	94.1	174.1

Table 5-22: Modelled Relative Savings (weighted average) in Travel Time (%) with the toll road compared to without the toll road

	2007	2012	2022	2037
WEEK AM	2.8%	6.2%	10.7%	14.6%
WEEK OP	6.8%	9.5%	17.5%	17.5%
WEEK PM	8.8%	11.5%	20.7%	22.3%

5.8 EXPECTED FUTURE TRAFFIC DEMAND

5.8.1 EXPECTED DEMAND WITHOUT TOLL

The toll eligible traffic can be determined from the traffic model by selecting a zero toll tariff. Runs were performed with the traffic model for the Weekday AM peak period for the case where no toll is levied. The AADT was estimated from the values by assuming that the Weekday AM peak hour represents 8% of the AADT (a typical figure in an urban area). The resulting traffic through the plazas, for the realistic, pessimistic and optimistic scenarios, for the years 2007 (base year), 2012 (end of first 5-year period), 2022 (end of 15-year period) and 2037 (end of 30-year evaluation period), is indicated in Table 5-23.

Table 5-23: Estimated Traffic on Proposed Opebi Mende Link Road When No Toll is Levied

Year	Mainline	Ramp Plaza 1	Ramp Plaza 2
REALISTIC SCENARIO			
2007	51,450	13,288	11,050
2012	60,400	13,588	11,325
2022	83,288	15,400	11,000
2037	96,388	14,413	12,375
PESSIMISTIC SCENARIO			
2007	51,450	13,288	11,050
2012	57,225	13,888	11,213
2022	70,625	14,725	11,550
2037	70,625	14,725	11,550
OPTIMISTIC SCENARIO			
2007	51,450	13,288	11,050
2012	62,638	14,088	11,138
2022	95,650	14,538	12,138
2037	131,013	15,375	15,500

5.8.2 EXPECTED DEMAND WITH TOLLS

By entering a toll tariff into the traffic model, the impact of tolling on the utilisation of the proposed Opebi-Mende Link Road can be determined. Various toll tariffs were evaluated to determine the optimum toll tariff (the tariff rendering the highest revenue). The appropriate toll tariff was selected as Naira 100 (for Class I vehicles through the mainline), as discussed in earlier sections.

The resulting traffic through the toll plazas for the toll tariff of Naira 100 is indicated in Table 5-24. This traffic is presented for the realistic, pessimistic and optimistic scenarios, for the years 2007 (base year), 2012 (end of first 5-year period), 2022 (end of 15-year period) and 2037 (end of 30-year evaluation period), and for a VOT of 100 and 200 Naira per hour respectively.

Table 5-24: Expected Toll Traffic Demand

	VOT = 100			VOT = 200		
	Mainline	**Ramp 1**	**Ramp 2**	**Mainline**	**Ramp 1**	**Ramp 2**
REALISTIC SCENARIO						
2007	10,760	3,490	1,000	19,280	5,900	2,680
2012	14,780	3,800	1,290	29,170	6,220	3,370
2022	43,600	5,860	3,610	61,380	7,910	5,730
2037	67,920	6,380	5,730	85,670	9,280	8,010
PESSIMISTIC SCENARIO						
2007	10,760	3,490	1,000	19,280	5,900	2,680
2012	15,430	3,830	1,350	26,290	6,150	3,230
2022	30,040	3,980	2,390	44,910	6,820	4,390
2037	30,040	3,980	2,390	44,910	6,820	4,390
OPTIMISTIC SCENARIO						
2007	10,760	3,490	1,000	19,280	5,900	2,680
2012	20,370	3,690	1,590	33,470	6,230	3,700
2022	65,830	6,220	5,450	83,760	8,860	7,760
2037	122,930	10,010	10,710	135,740	13,800	12,600

5.8.3 TOLL ATTRACTION OF TOLL PLAZAS

The toll attraction of the toll plazas can be determined by comparing the traffic through the plazas when toll is applied, to the toll eligible traffic (situation without any tolls). The toll attraction is summarised in Table 5-25.

Table 5-25: Toll Attraction of Toll Plazas

	MAINLINE	RAMP 1	RAMP 2	MAINLINE	RAMP 1	RAMP 2
	VOT = 100			VOT = 200		
REALISTIC SCENARIO						
2007	20.9%	26.3%	9.0%	37.5%	44.4%	24.3%
2012	24.5%	28.0%	11.4%	48.3%	45.8%	29.8%
2022	52.3%	38.1%	32.8%	73.7%	51.4%	52.1%
2037	70.5%	44.3%	46.3%	88.9%	64.4%	64.7%
PESSIMISTIC SCENARIO						
2007	20.9%	26.3%	9.0%	37.5%	44.4%	24.3%
2012	27.0%	27.6%	12.0%	45.9%	44.3%	28.8%
2022	42.5%	27.0%	20.7%	63.6%	46.3%	38.0%
2037	42.5%	27.0%	20.7%	63.6%	46.3%	38.0%
OPTIMISTIC SCENARIO						
2007	20.9%	26.3%	9.0%	37.5%	44.4%	24.3%
2012	32.5%	26.2%	14.3%	53.4%	44.2%	33.2%
2022	68.8%	42.8%	44.9%	87.6%	60.9%	63.9%
2037	93.8%	65.1%	69.1%	103.6%	89.8%	81.3%

It is evident from Table 5-25 that a VOT of 200 Naira per hour results in much higher attraction rates compared to a VOT of 100 Naira per hour.

5.9 CAPACITY AND OPERATIONAL ANALYSIS

The number of lanes required on the Opebi Mende Link Road, and the resulting capacity, was calculated by means of the procedure prescribed in the Highway Capacity Manual (HCM2000).

The following parameters were accepted for these calculations:

- ⇨ Interchange density of 2.5 kilometre;
- ⇨ Lane width of 3.6 meters;

- ⇨ Terrain level;
- ⇨ % Trucks of 4%;
- ⇨ Free flow speed of 100 km/h;
- ⇨ Peak hour factor of 0.95;
- ⇨ Peak hour coefficient of 10%; and
- ⇨ Directional split of 60%.

The maximum AADT levels for the various Levels of Service (LOS) for a 4-lane, a 6-lane and an 8-lane freeway are shown in Table 5-26.

Table 5-26: Level of Service Definition based on AADT

	4-Lane Freeway	**6-Lane Freeway**	**8-Lane Freeway**
LOS A	< 19,200	< 30,000	< 41,700
LOS B	< 30,800	< 47,500	< 65,000
LOS C	< 45,000	< 69,200	< 95,000
LOS D	< 60,800	< 91,700	< 125,800
LOS E	< 69,200	< 105,800	< 140,800
LOS F	> 69,200	> 105,800	> 140,800

The required number of lanes to maintain a minimum LOS D is shown in Table 5-27.

Table 5-27: Number of lanes required for LOS D on Opebi-Mende Link road

	Realistic Scenario		**Pessimistic Scenario**		**Optimistic Scenario**	
	VOT = 100	**VOT = 200**	**VOT = 100**	**VOT = 200**	**VOT = 100**	**VOT = 200**
2007	4	4	4	4	4	4
2008	4	4	4	4	4	4
2009	4	4	4	4	4	4

	Realistic Scenario		Pessimistic Scenario		Optimistic Scenario	
	VOT = 100	VOT = 200	VOT = 100	VOT = 200	VOT = 100	VOT = 200
2010	4	4	4	4	4	4
2011	4	4	4	4	4	4
2012	4	4	4	4	4	4
2013	4	4	4	4	4	4
2014	4	4	4	4	4	4
2015	4	4	4	4	4	4
2016	4	4	4	4	4	4
2017	4	4	4	4	4	4
2018	4	4	4	4	4	6
2019	4	4	4	4	4	6
2020	4	4	4	4	4	6
2021	4	4	4	4	6	6
2022	4	6	4	4	6	6
2023	4	6	4	4	6	6
2024	4	6	4	4	6	6
2025	4	6	4	4	6	8
2026	4	6	4	4	6	8
2027	4	6	4	4	6	8
2028	4	6	4	4	6	8
2029	4	6	4	4	8	8
2030	4	6	4	4	8	8
2031	4	6	4	4	8	8
2032	4	6	4	4	8	8
2033	6	6	4	4	8	8
2034	6	6	4	4	8	8
2035	6	6	4	4	8	8
2036	6	6	4	4	8	8
2037	6	6	4	4	8	8

5.10 RECOMMENDATIONS

The maximum utilisation of the proposed Opebi-Mende Link can only be obtained by ensuring that the approaches to the toll road are able to handle the maximum flow that can be expected on the Opebi Mende Link.

This implies the following:

- ⇨ The current linkage road between Opebi Road and Bank Anthony Road must be upgraded to have at least the same capacity as the proposed Opebi-Mende Link, and the intersection/circle which provides access to the proposed link must be well designed and operate efficiently;

- ⇨ The intersections of the above mentioned road with Bank Anthony Road and the existing Opebi Road are to be upgraded to efficiently accommodate the expected increase in traffic at these intersections; and

- ⇨ The ramps connecting the proposed Opebi-Mende Link with the surrounding road network must be of high standard and have sufficient capacity to maintain high levels of accessibility.

It is further recommended that the following network layout be adopted in the feasibility study of the Opebi-Mende Link Road:

- ⇨ Network Alternative 2 should be selected as the network configuration. Therefore, the road should commence in the west at Opebi Link Road, proceed east with an interchange on Ikorodu Road, and join the 3rd Mainland Bridge with an interchange. The total length of this road will be 3.685km.

- ⇨ Two interchanges should form part of the proposed Opebi-Mende Link Road, namely a partial systems interchange between the Opebi-Mende Link Road and Ikorodu Road, with access only to and from the south. The second interchange should be a clover interchange between the Opebi-Mende Link Road and the 3rd Mainland Bridge, providing full access to and from the 3rd Mainland Bridge.

- ⇨ It is recommended to construct one Mainline toll plaza to the east of the Opebi-Mende Link Road / Ikorodu Road Interchange, as well as two ramp plazas (from south to west and from west to south) at the Ikorodu Interchange.

6 TRAFFIC INVESTIGATION: LEKKI CORRIDOR

6.1 INTRODUCTION

6.1.1 DESCRIPTION OF PROJECT

6.1.1.1 Lekki Corridor

The narrow strip of land extending eastwards from Victoria Island and its Annexes, which is bordered by the Lagos Lagoon in the north and the Bight of Benin of Gulf of Guinea in the south, is known as the Lekki Corridor. This strip of land is about 1km wide at its most narrow section close to the islands but widens out to about 8km at km 20 (the intersections of Maroko Road and the new Coastal Freeway with Falomo Bridge and Akin Adesola Road respectively have been designated as chainage 0, i.e. km 0).

Although this corridor extends approximately 105km to the border with Olokola State, the first 50km is particularly important for the purposes of this investigation.

This corridor is currently served by a single east-west multi-lane highway, known as the Epe Expressway. The first section of this road, from Falomo Bridge to the Exxon Headquarters, has federal status and is known as Maroko Road.

A Coastal Road alongside the shoreline has been planned for many years by the State of Lagos. No other east-west facilities have been planned in this corridor. The establishment of townships on an ad hoc basis – driven by private sector – have however resulted in the development of a secondary supporting road network, which is largely "disconnected and discontinuous". All the current desire lines for travel, and consequently the roads that serves these desire lines is in a north-south direction connecting to Epe Expressway. This is clearly an unsustainable situation, which limits the development potential of this corridor significantly.

Figure 6-1 shows the study area and locality plan.

Figure 6-1: Study Area and Locality Plan

6.1.1.2 Lekki Corridor with Southern Bypass

The limited available road infrastructure on the islands remains one of the greatest bottlenecks for the growth and development of the whole area. This includes the development of the Lekki Corridor since all the movement between the Mainland and the Lekki Corridor has to transverse the congested islands.

Currently the primary connection from the Mainland to the Lekki Corridor is via Kingsway Road in Ikoyi. This street however is heavily congested with high friction due to a lack in proper traffic control and access management. The use of Kingsway Road using Falomo Bridge to cross Five Cowrie Creek furthermore concentrates traffic in Maroko Road, which results in the saturation of this road. Even with the new Coastal Road, traffic will find it difficult to reach the starting point at the Akin Adesola Road / New Coastal Freeway Interchange given the congestion in Kingsway Road and Akin Adesola Road.

Figure 6-1 shows the study area and locality plan.

6.1.2 RATIONALE AND JUSTIFICATION OF PROJECT

6.1.2.1 Lekki Corridor

The Lekki Peninsula (as the area closer to the islands is known) has experienced rapid growth during recent years. This area is ideally located to serve as a natural hinterland for the expansion of Lagos given that it is not separated from the islands by any geographical obstacles such as the Lagos Lagoon that separates the Mainland from Lagos and Victoria Islands.

A single multi-lane urban arterial, the Epe Expressway, serves as an east-west spine that connects all activities in this corridor. The Epe Expressway was build as a four-lane “divided” facility from the Falomo Bridge (connects Kingsway Road on Lagos Island across the Five Cowrie Creek to Akin Adesola Street on Victoria Island) to the crossing of the Lagos Lagoon in the east, approximately 60km from Falomo Bridge. Unfortunately, this important facility has been poorly developed and is not management as it should be:

- ⇨ Proper storm water drainage is almost non-existent;
- ⇨ All movements through the median is allowed;
- ⇨ No shoulders are provided;
- ⇨ Friction from non-motorised transport (NMT) and pedestrians is high, and
- ⇨ No access management is practiced.

The detrimental impact of these design limitations and lack in management is evident in its low capacity and poor operating characteristics. The section of this road serving the Lekki Peninsula is already suffering from saturated and congested traffic flow conditions during peak hours.

The primary weakness of the road network in this corridor however is the lack in a supporting road network and a hierarchical network structure. This results in the sub optimal utilization of Epe Expressway and slow destruction of its functionality.

The development potential of the Lekki Corridor can only be unlocked through the provision of appropriate road infrastructure. Given the shortfall in available funding from government for this purpose, private sector has offered to invest in this corridor through a BOT concession for a period of at least 30 years:

- ⇨ The upgrading of Epe Expressway to a six-lane facility with proper shoulders, a median that restricts movement, properly spaced intersections at 2 to 3 km, street lighting, and with limited pedestrian activities in the ROW (ROW of 60m and design speed of 80 km/h);
- ⇨ The construction of a new Coastal Freeway that can ultimate be expanded to a eight-lane facility with limited access (ROW of 80m and design speed of 100 km/h); and
- ⇨ The construction of 10 interconnecting link roads between Epe Expressway and the new Coastal Freeway.

The planned cross-section of the Coastal Freeway will make provision for exclusive Bus Rapid Transit (BRT) lanes to serve public transport in this corridor.

6.1.2.2 Lekki Corridor with Southern Bypass

The construction of the Southern Bypass on the alignment of Ahmadu Bello Way on the western and southern shores of Victoria Island and the construction of a new direct link between the eastern Ring Road on Lagos Island and the Southern Bypass was identified during the pre-feasibility study. The total length of the planned Southern Bypass is less than 3.5km. The obvious benefits of this new road linkage are the following:

- ⇨ It will increases the capacity of the routes through Lagos Island/Ikoyi to Victoria Island and the Lekki Corridor;
- ⇨ It will provide an alternative route (to the congested Kingsway Road) through Lagos Island and Ikoyi for traffic destinated to both Victoria Island and the Lekki Corridor;

- ⇨ The eastern section of the Ring Road still has spare capacity during peak periods that can now be utilised;
- ⇨ It serves the western end of the new Costal Freeway directly, which will simultaneously decreases the flows on the congested Maroko Road.

The proposal to construct the Southern Bypass will result in an overall improvement in the distribution of traffic on the islands (which will improve traffic flow on Lagos Island and Ikoyi) and it will benefit the development of the Lekki Corridor. It will furthermore assist to redistribute traffic effectively from Maroko Road/Epe Expressway (with no spare capacity) to the new Coastal Freeway (with spare capacity). It is hence proposed to construct a new four-lane facility that can be upgraded to six-lanes in addition to the existing Ahmadu Bello Way, which will become two-lane frontage roads on both sides of the new freeway. Ahmadu Bello Way will provide access while the Southern Bypass will prove mobility.

It is however, an engineering challenge given the narrow available ROW. Reinforced earth walls will be used to elevate the Southern Bypass which will not only provide the required lateral clearance but it will enable the linking of Ahmadu Bello Way and other streets underneath the Southern Bypass. The Southern Bypass and Ahmadu Bello Way will only be linked through ramps at Ozumba Mbadiwe and at Akin Adesola.

Ahmadu Bello Way is currently a federal road.

6.1.3 APPROACH AND METHODOLOGY

The viability of the Lekki Corridor without and with the Southern Bypass was investigated based on the expected toll traffic demand and hence the expected revenue that can be collected during a concession period. The willingness-to-pay and affordability of toll tariffs (influenced strongly by motorists value of time (VOT)), that influences the toll attraction, is a key issue that was addressed. See also Section 0. Although no free alternatives are available in the Lekki Corridor (both the existing but upgraded Epe Expressway and the new Coastal Freeway will be tolled), it can be expected that some traffic will be suppressed not to make journeys, to make shorter journeys or to use the supporting secondary road network. Very limited opportunities are however available to avoid the planned toll plazas altogether.

The determination of the toll traffic demand is key to the viability investigation. Towards this end, a transportation-planning model was calibrated and used to forecast traffic flows on the network. Two basic network scenarios were subsequently investigated, namely the Lekki Corridor and the Lekki Corridor with the Southern Bypass. The same transportation model was used for these purposes.

6.2 NETWORK DESCRIPTION

6.2.1 EXISTING ROAD NETWORK

Major roads in the study area are shown below. These roads form the main network for accessibility between the Mainland, Lagos Island and the Lekki Peninsula.

Table 6-1: Major Roads in the study area

Roads	Description
Third Mainland Bridge	Freeway with 6 lanes
Ikoyi Road	
Adeniyi Adele Road	
New Marina Road	
Epe Express Way	Dual carriageway road with 4 lanes (Rural and Sub-Urban)
Eko Bridge	High Standard Dual carriageway road with 4 lanes (Urban)
Osborne Road	
Kingway Road	
Akin Adesola Street	
Ahmadu Bello Road	
Ozumba Mbadiwe Avenue	Low Standard Dual carriageway road with 4 lanes (Urban)
Maroko Road	
New Cater Bridge	
Awolowo Road	Undivided roads with 4 lanes (Urban)

The existing traffic demand was determined from traffic counts conducted in 2004, with the addition of some earlier counts in 2003. The traffic surveys and detailed results are described in detail in later sections of this report, but an extract of the current traffic demand and operating conditions is given in Table 6-2 and Table 6-3 below. These tables summarize the existing 2004 ADT, peak hour flows and operating conditions (levels-of-service (LOS) and volume-to-capacity ratios (V/C)).

Figure 6-2 shows the survey locations.

Figure 6-2: Survey Locations

Table 6-2: Average Daily Traffic Volumes - 2004

Survey Location	Vehicle Class			
	Light Vehicles	Public Service Vehicles	Heavy Vehicles	TOTAL
L1	22,163	8,472	2,381	**33,017**
L2	26,675	8,661	2,116	**37,451**
L3	33,588	9,939	1,840	**45,367**
L4	38,585	10,156	2,244	**50,985**
L5	57,377	5,371	2,142	**64,890**
L6	20,515	6,684	847	**28,045**
L7	54,784	13,725	2,262	**70,770**
L8	16,369	2,572	287	**19,228**
L9	24,782	5,201	567	**30,550**
Eco Bridge	50,149	20,364	1,754	**72,267**
Carter Bridge	17,913	27,207	3,082	**48,202**
3rd Mainland Bridge	68,858	16,130	1,448	**86,435**
Epe 13	5,672	2,181	599	**8,451**
Epe 14W	2,216	838	231	**3,285**

Table 6-3: Critical Hour Traffic Flows, LOS and V/C - 2004

Survey Location	Critical Hour Traffic Volume	Directional Split	Levels-of-Service (LOS)	Volume / Capacity (V/C)
L1	3,479	52 : 48	C	0.75
L2	3,778	52 : 48	C	0.82
L3	4,471	50 : 50	D	0.93
L4	5,346	51 : 49	E	1.14
L5	6,072	59 : 41	F	1.49
L6	2,617	40 : 60	C	0.65
L7	7,148	49 : 51	F	1.52
L8	2,120	35 : 65	B	0.57
L9	3,069	55 : 45	C	0.70
Eco	10,651	29 : 71	F	1.40
Carter	6,716	97 : 3	F	1.81
3rd Main	8,754	50 : 50	D	0.81
Epe 13	994	46 : 54	A	0.22
Epe 14 W	460	41 : 59	A	0.11

assuming PHF for period = 0.75

The congested conditions close to the islands are evident, namely survey position L4 and L5.

The majority of trips are work related (commuter or general business trips), and a significant number these also occur on Saturdays and Sundays. However, the shopping / leisure peaking characteristics on Saturday and especially on Sunday is noticeable. Data on the trip purposes was obtained from roadside interviews in 2004, and are described in detail in later sections of this report. The results are summarised below:

Table 6-4: Trip Purposes

Period	Business	Education	Home-work (commuter)	Shop / leisure	Total
Weekday	61%	1%	27%	10%	100%
Sat	52%	1%	15%	33%	100%
Sun	37%	1%	9%	53%	100%

6.2.2 FUTURE ROAD NETWORK

The future planned road network will entail the following:

- ⇨ Upgrading of Falomo Bridge to allow for a direct east-to-north on-ramp and a north-to-south off-ramp;
- ⇨ Upgrading of Maroko/Epe Expressway to a six-lane facility from Falomo Bridge to the planned 4th Mainland Bridge Link;
- ⇨ Upgrading of Maroko/Epe Expressway to a proper four-lane facility with shoulders, a divided median and access control, from the planned 4th Mainland Bridge Link to the Eleko Beach turn-off;
- ⇨ Construction of a new Coastal Freeway as a six-lane and four-lane limited access facility from Akin Adesola to Eleko Beach;
- ⇨ Construction of 10 connecting roads between Epe Expressway and Coastal Freeway; and
- ⇨ Construction of new Southern Bypass on the alignment of Ahmadu Bello Way and new directionals between the eastern Ring Road on Lagos Island and the Southern Bypass.

Two basic network alternatives were investigated namely without and with the Southern Bypass. The road network upgrading that is required, i.e. 2-lanes, 4-lanes, and 6-lanes, versus what can be afforded from a tolling point of view was investigated for every network alternative.

6.2.3 SCENARIOS AND DESIGN YEARS (PERIODS)

For the purpose of this viability analyses, the concession period of 30 years was divided into three distinctive periods for which different growth rate assumptions were made. Lower growth rates are generally assumed for periods further into the future given increasing uncertainties. These periods were chosen as follows:

- ⇨ 2007 to 2012 i.e. 5-years;
- ⇨ 2013 to 2022 i.e. 10-years;
- ⇨ 2023 to 2037 i.e. 15-years

More optimistic and more pessimistic growth assumptions were furthermore made in addition to the expected (realistic) assumptions to test the sensitivity of the financial model for variations in traffic growth.

Based on the assumed growth rate in attractions (expected future growth in GDP) and assumed growth rate in productions (expected future growth in population), the following growth rates were calculated by the transportation-planning model. These growth rates are reported for different screen lines in the corridor, which was chosen to coincide with the positions of the toll plazas. Figure 6-3 shows these locations schematically.

Table 6-5 and Table 6-6 shows the various growth rates for the Lekki Corridor and the Lekki Corridor with the Southern Bypass respectively.

Figure 6-3: Location of Toll Plazas and Screen lines

Table 6-5: Modelled Future Growth Rates: Lekki Corridor

SCENARIO: LEKKI CORRIDOR				
Location	2007 2012	2012 2022	2022 2037	2007 2037
REALISTIC				
Screen line 1	7.0%	5.2%	3.6%	4.7%
Screen line 2	7.1%	6.0%	3.8%	5.1%
Screen line 3	7.9%	6.4%	4.3%	5.6%
All	7.2%	5.6%	3.8%	4.9%
PESSIMISTIC				
Screen line 1	6.0%	4.2%	2.6%	3.7%
Screen line 2	6.1%	5.1%	2.9%	4.1%
Screen line 3	6.9%	5.6%	3.4%	4.7%
All	6.2%	4.7%	2.8%	4.0%
OPTIMISTIC				
Screen line 1	8.0%	6.2%	4.6%	5.7%
Screen line 2	8.1%	6.8%	4.7%	6.0%
Screen line 3	8.9%	7.2%	5.3%	6.5%
All	8.2%	6.5%	4.8%	5.9%

Table 6-6: Modelled Future Growth Rates: Lekki Corridor with Southern Bypass

SCENARIO: LEKKI CORRDIOR WITH SOUTHERN BYPASS				
Location	2007 2012	2012 2022	2022 2037	2007 2037
REALISTIC				
Screen line 1	6.2%	5.0%	3.7%	4.5%
Screen line 2	6.6%	6.0%	3.8%	5.0%
Screen line 3	7.6%	6.7%	4.4%	5.7%
Screen line All	6.5%	5.5%	3.8%	4.8%
S Bypass 1	7.7%	6.4%	4.5%	5.7%
S Bypass 2	35.4%	12.0%	5.7%	12.3%
S Bypass 3	28.6%	8.8%	4.8%	9.8%
S Bypass All	14.8%	8.1%	4.9%	7.6%
All	8.8%	6.5%	4.3%	5.7%
PESSIMISTIC				
Screen line 1	5.2%	4.0%	2.7%	3.5%

SCENARIO: LEKKI CORRDIOR WITH SOUTHERN BYPASS				
Location	**2007**	**2012**	**2022**	**2007**
	2012	**2022**	**2037**	**2037**
Screen line 2	5.6%	5.2%	2.9%	4.1%
Screen line 3	6.6%	5.9%	3.5%	4.8%
Screen line All	5.5%	4.6%	2.9%	3.9%
S Bypass 1	6.7%	5.4%	3.5%	4.7%
S Bypass 2	34.4%	11.0%	4.7%	11.3%
S Bypass 3	27.6%	7.8%	3.8%	8.8%
S Bypass All	13.8%	7.2%	3.9%	6.6%
All	7.9%	5.5%	3.3%	4.8%
OPTIMISTIC				
Screen line 1	7.2%	6.0%	4.7%	5.5%
Screen line 2	7.6%	6.9%	4.8%	5.9%
Screen line 3	8.6%	7.5%	5.4%	6.6%
Screen line All	7.5%	6.5%	4.8%	5.8%
S Bypass 1	8.7%	7.4%	5.5%	6.7%
S Bypass 2	36.4%	13.0%	6.7%	13.3%
S Bypass 3	29.6%	9.8%	5.8%	10.8%
S Bypass All	15.8%	9.1%	5.8%	8.5%
All	9.8%	7.4%	5.2%	6.7%

6.3 TRAFFIC SURVEYS

The data collection and traffic modelling for the proposed Southern Bypass and the Coastal Road were conducted as a single project based on the close proximity and interrelation between these projects. Much of the data collected for the pre-feasibility report on these projects in November 2003 was also focussed on the area, which provided some historic background information on traffic flows.

6.3.1 DESCRIPTION OF TRAFFIC SURVEYS

6.3.1.1 Traffic Survey Strategy

The traffic surveys for the Feasibility Study were an expansion on those conducted in November 2003 for the Pre-Feasibility Study. The traffic survey strategy therefore considered what was learnt from the previous surveys, and focussed on specific areas where information that is more detailed was required.

The traffic surveys comprised of four components:

- ⇨ Manual classified traffic counts;
- ⇨ Origin-destination (O-D) surveys;
- ⇨ Travel-time surveys; and
- ⇨ Electronic traffic counts.

The manual traffic counts and O-D-surveys were conducted simultaneously at nine strategic survey locations on Victoria Island and the Lekki Peninsula. The selection of these locations was based on the layout of the Projects and available historic traffic information. Travel times were measured on the routes included in the Projects to be investigated, as well as the alternative routes that may be taken to evade toll plazas. An electronic traffic count was conducted at a single location over an extended period to determine the 24-hour traffic flow profile for each day over a typical week.

6.3.1.2 Manual Counts and O-D Surveys

The manual traffic counts and O-Ds were conducted at each of the nine strategic locations between 06:00 and 20:00 for two typical weekdays. Two of these locations were identified as control points, and were surveyed for a third weekday (control count with more detailed vehicle classification), a Saturday and a Sunday. An additional four locations were also surveyed on either a Saturday or a Sunday.

The field surveys, for which the locations are indicated on Figure 6-2, are listed in Table 6-7 below:

Table 6-7: Manual Survey Locations and Programme

Date	Day	Location								
		L1	L2	L3	L4	L5	L6	L7	L8	L9
5 Aug '04	Thu	C OD	C OD							
6 Aug '04	Fri	C OD	C OD							
7 Aug '04	Sat									
8 Aug '04	Sun	C OD	C OD							
9 Aug '04	Mon			C OD	C OD	C OD				
10 Aug '04	Tue			C OD	C OD	C OD				

Date	Day	Location								
		L1	L2	L3	L4	L5	L6	L7	L8	L9
11 Aug '04	Wed						C OD	C OD	C OD	
12 Aug '04	Thu						C OD	C OD	C OD	
13 Aug '04	Fri		CC					CC		C OD
14 Aug '04	Sat		C OD			C OD		C OD		
15 Aug '04	Sun				C OD		C OD	C OD		
16 Aug '04	Mon								C OD	C OD

C = Classified Manual Counts / OD = Origin-Destination Interviews / CC = Control Counts

During the classified manual traffic counts, vehicles were counted in 15-minute intervals. Vehicles were classified into:

- ⇨ Car: Light vehicles, excluding motorcycles
- ⇨ Taxi: Danfo, molue, medium and small staff buss
- ⇨ Heavy: Trucks and large buses

For the Control Counts (two locations), the vehicle classification was expanded to include the following classes:

- ⇨ Car
- ⇨ Pick-ups and Sports Utility Vehicles (SUVs)
- ⇨ Danfo
- ⇨ Molue
- ⇨ Large bus
- ⇨ Rigid trucks (2-axle, 3-axle or 4-axle)
- ⇨ Truck & Trailer (4-axle, 5-axle, 6-axle or 7-axle)
- ⇨ Truck & Semi-Trailer (3-axle, 4-axle, 5-axle, 6-axle or 7-axle)

For the purpose of the O-D-surveys and analysis, 12 traffic zones were identified (see Figure 6-4).

The following information was obtained from the interviews:

- ⇨ Time of interview
- ⇨ Vehicle class (Car, Taxi, Bus, Truck)
- ⇨ Origin zone
- ⇨ Destination zone
- ⇨ Trip purpose
- ⇨ Frequency of Trip
- ⇨ Distance of Trip
- ⇨ Travel Time
- ⇨ Vehicle owned by driver (Y/N)

6.3.1.3 Electronic Traffic Counts

An electronic traffic counter was used to count vehicles on Maroko Road, west of the intersection with Samuel Manuwa Street (see Figure 6-2). A count was conducted from 9 to 17 August 2004, and again from 19 September to 4 October 2004. The counter provided valuable uninterrupted information for an extended period of time, from which the day-to-day fluctuations and the nighttime profiles was obtained.

6.3.1.4 Travel-Time Surveys

Travel time surveys were conducted on Lagos Island, Obalende, Ikoyi Island, Victoria Island, Victoria Island Annex and Lekki Peninsula during the period from 3 to 13 August 2004. Travel times were recorded on routes between nodes at different times of the day and at different levels of traffic congestion. Routes were selected according to their functional class and importance in future traffic modelling.

Figure 6-4: Traffic Zones for Lekki Corridor

The following routes were selected and surveyed:

- ⇨ New Marina Road
- ⇨ Ikoyi Road
- ⇨ Adeniji Adele Road
- ⇨ Osborne Road
- ⇨ Kingsway Road
- ⇨ Awolowo Road
- ⇨ Ahmadu Bello Road
- ⇨ Akin Adesola Street
- ⇨ Ozumba Mbadiwe Avenue
- ⇨ Maroko Road
- ⇨ Epe Express Way

All these routes fall with in the Project study area and represent direct and alternative routes.

6.3.2 RESULTS OF TRAFFIC SURVEYS

6.3.2.1 Manual Traffic Counts

The results of the traffic counts were consolidated from 15-minute to 60-minute intervals for the purpose of this report. From the counts, it was evident that the road network is over saturated, and peak spreading occurs on weekdays and even Saturdays. Traffic volumes are therefore high throughout the day.

In summary, the surveyed 14-hour traffic volumes (06:00 – 20:00) for each day of survey were as given in Table 6-8:

Table 6-8: Observed Traffic Volumes, 2004 (06:00-20:00)

Day of Survey	Class	Survey Location								
		L1	L2	L3	L4	L5	L6	L7	L8	L9
Weekday 1 (NB / EB)	Car	8,933	10,835	12,431	15,654	27,607	7,018	23,807	6,758	13,861
	Taxi	3,395	3,623	4,340	4,171	1,345	2,067	7,408	938	2,356
	Heavy	1,152	1,120	693	761	1,157	416	839	134	433
	TOT	**13,480**	**15,578**	**17,464**	**20,586**	**30,109**	**9,501**	**32,054**	**7,830**	**16,650**
Weekday 1 (SB / WB)	Car	9,388	11,863	15,841	16,140	28,327	11,086	25,296	8,467	9,894
	Taxi	4,063	3,612	4,925	5,306	3,483	3,722	5,487	1,454	2,339
	Heavy	1,020	946	971	829	1,026	412	1,199	140	197
	TOT	**14,471**	**16,421**	**21,737**	**22,275**	**32,836**	**15,220**	**31,982**	**10,061**	**12,430**
Weekday 2 (NB / SB)	Car	9,314	10,378	11,244	14,868	25,466	7,878	26,456	6,471	13,616
	Taxi	3,216	3,576	3,430	4,232	1,330	2,121	7,391	920	2,573
	Heavy	1,347	1,013	912	1,470	1,157	499	1,129	135	292
	TOT	**13,877**	**14,967**	**15,586**	**20,569**	**27,953**	**10,498**	**34,976**	**7,526**	**16,481**
Weekday 2 (SB / WB)	Car	9,508	11,386	15,937	17,641	25,413	11,178	27,858	8,873	9,595
	Taxi	4,038	4,157	4,284	4,062	3,732	4,183	4,974	1,411	2,394
	Heavy	985	945	878	1,144	599	315	1,371	159	224
	TOT	**14,531**	**16,488**	**21,099**	**22,847**	**29,744**	**15,676**	**34,203**	**10,443**	**12,213**
Saturday (NB / SB)	Car		12,750			20,535		18,506		
	Taxi		3,628			1,015		5,917		
	Heavy		864			923		543		
	TOT		**17,242**			**22,473**		**24,966**		
Saturday (SB / WB)	Car		11,794			20,408		15,980		
	Taxi		3,781			2,914		4,093		
	Heavy		959			1,245		756		
	TOT		**16,534**			**24,567**		**20,829**		
Sunday (NB / SB)	Car	8,506	10,250		13,593		6,153	13,351		
	Taxi	2,736	3,140		3,034		1,371	4,022		
	Heavy	355	289		321		175	169		
	TOT	**11,597**	**13,679**		**16,948**		**7,699**	**17,542**		
Sunday (SB / WB)	Car	8,142	10,934		14,859		8,302	12,935		
	Taxi	2,927	2,977		2,875		2,562	2,838		
	Heavy	330	289		312		136	358		
	TOT	**11,399**	**14,200**		**18,046**		**11,000**	**16,131**		

6.3.2.2 Manual Control Counts

The manual control counts were conducted to determine the composition of traffic within the three general classes used for the other manual counts. In summary, the traffic composition at the two selected survey locations were as given in Table 6-9.

From the table it can be seen that light vehicles traffic contributes to between 70% and 80% of the total traffic. The proportion of public service vehicles, mostly Danfo, is in the order of 20%. It will further be noted that the percentage heavy vehicles is very low on the Islands (L7). Approximately 5% of vehicles on the Lekki Peninsula (L2) are heavy vehicles (mostly rigid 2-axle trucks) and this is attributed to the rapid development and many construction sites on the Lekki Peninsula.

Table 6-9: Traffic Composition obtained from Control Counts

Vehicle Class	Survey Location L2		Survey Location L7	
	Eastbound (EB)	Westbound (WB)	Northbound (NB)	Southbound (SB)
Car	63.0%	62.4%	68.2%	73.5%
Pick-up	10.2%	11.8%	8.1%	8.4%
Danfo	20.6%	19.4%	21.7%	15.7%
Molue	0.7%	0.7%	0.5%	0.7%
Bus	0.0%	0.1%	0.2%	0.0%
Rigid Truck	4.2%	4.6%	1.1%	1.5%
Truck trailer	0.0%	0.0%	0.0%	0.0%
Semi-trailer	1.3%	0.9%	0.2%	0.2%
TOTAL	**100.0%**	**100.0%**	**100.0%**	**100.0%**

6.3.2.3 Electronic Traffic Counts

The electronic count was conducted on Victoria Island, on Maroko Road. The electronic counts did not reveal a typical commuter peaking profile, although the demand during the morning and afternoon peak period appear to be far higher than during the day. The reason is that, due to the severely congested road network, peak spreading occurs – much of the peak period traffic demand is only satisfied during the off-peak, i.e. the peak period traffic overspills into the off-peak period. The off-peak traffic volumes are therefore not much lower than during the peak periods. This is an indication of severely congestion traffic conditions.

Some of the key results of the electronic traffic counts are shown below:

Table 6-10: Electronic Count Results (7 days)

Average Daily Traffic (ADT)	39 728
Average Peak Hour Traffic (VPH)	5 133
VPH as percentage of ADT	12.9%
Night Traffic (18:00-06:00)	13 786
Night Traffic as percentage of ADT	34.7%

6.3.2.4 Travel-Time Surveys

About 340 node-to-node travel time surveys were recorded over a period of eight days on routes in the study area in both directions. The distances between nodes were obtained from GPS readings. The travel times and distances between nodes were aggregated to give route performance data at different times of the day. Data were compared and arranged according to available hourly traffic flow data.

The maximum-recorded speed was 99 km/h on Epe Express Way between Admirality Circle and Lekki Circle and the minimum recorded speed was 7 km/h on Ozumba Mbadiwe Avenue between Akin Adesola Street and Ahmadu Bello Road. The average speed was 34 km/h. The average speed on all node-to-node surveys was 44 km/h.

All available travel times were used to evaluate how realistic the base year output of the traffic flow model is for different routes and different periods of the day.

6.3.2.5 Origin-Destination Information

The origin-destination (OD) data provided the basis for the development of trip distribution matrices. More than 27 000 drivers were interviewed at the nine survey locations on Victoria Island and the Lekki Peninsula. The interviewed samples, as a percentage of the total traffic through the survey locations, were as follows:

Table 6-11: OD Samples as Percentage of Traffic Volume

Period	Survey Location									
	L1	**L2**	**L3**	**L4**	**L5**	**L6**	**L7**	**L8**	**L9**	**TOT**
Week 06:00-13:00	6%	6%	2%	4%	4%	11%	3%	13%	8%	***5%***
Week 13:00-20:00	6%	4%	4%	5%	5%	12%	3%	8%	7%	***5%***
Saturday 06:00-13:00	-	7%	-	-	8%	-	6%	-	-	***7%***

Period	Survey Location									
	L1	L2	L3	L4	L5	L6	L7	L8	L9	TOT
Saturday 13:00-20:00	-	5%	-	-	5%	-	5%	-	-	***5%***
Sunday 06:00-13:00	10%	9%	-	7%	-	17%	6%	-	-	***9%***
Sunday 13:00-20:00	8%	7%	-	4%	-	16%	4%	-	-	***7%***
All	***7%***	***6%***	***3%***	***5%***	***5%***	***13%***	***4%***	***10%***	***7%***	**6%**

The development of a representative vehicle matrix for different analysis periods and vehicle classes was an extensive exercise, and is described in more detail in **Section 6.4.4**. To provide a first indication of the most important trip Origins and Destinations, all data from the nine survey locations, all days of survey, were analysed together to establish an OD-matrix. From this matrix, the following preliminary findings were made:

Table 6-12: Trip Generation per Traffic Zone - Preliminary

Traffic Zone	Approximate Share in Total Trip Generation
Zone 5	± 21%
Zone 9	± 20%
Zone 1	± 17%
Zone 3	± 10%
Zone 7	± 9%
Zone 2	± 8%
Zone 8	± 6%
Zone 4	± 5%
Zone 6	± 5%
All Zones Combined	100%

From the above it can be seen that traffic zones 1, 5 and 9 each generate in the order of 20% of the total trips in the study area.

The matrix was also used to determine the most prominent OD pairs. It was found that approximately one third of all trips in the study area occurred between three OD-pairs:

Table 6-13: Most Prominent OD-pairs - Preliminary

OD-pair	Approximate Share in Total Trip Generation
Zone 1 to / from Zone 5	± 13%
Zone 1 to / from Zone 9	± 10%
Zone 3 to / from Zone 9	± 9%
All Zones Combined	± 34%

6.3.2.6 Other Results from Roadside Interviews

In addition to origin-destination data, information was also gathered on purpose, frequency, travel time and travel distance of the trip. The trip purpose data was specifically used to sub-divide the data for the respective market segments, while the trip frequency, travel time and travel distance were used to provide a first indication of parameters for the calibration of the traffic model.

The distribution of trip purposes obtained from the interviews is summarised below:

Table 6-14: Trip Purposes

Period	Business	Education	Home-work (commuter)	Shop / leisure	Total
Weekday	61%	1%	27%	10%	100%
Sat	52%	1%	15%	33%	100%
Sun	37%	1%	9%	53%	100%

From the above it can be seen how shopping and leisure trips increase over weekends. However, the business and commuter component remains strong even on Saturdays and Sundays.

The frequency at which a person goes on a specific trip (one-way) is summarised below:

Table 6-15: Frequency of Trips

(Frequency) Trips per week, one-way	Percentage
<1 per week	8%
1-10 times per week	76%
>10 times per week	15%

From the surveys, it was found that most people use the road on a daily basis for a similar trip. Less than 10% of people use the road on an infrequent basis (less than once a week), while approximately 75% of people embarked on a specific trip up to 10 times per week – these account for the high percentage of business and commuter trips, as found from the trip purpose information.

The typical distances travelled and the typical travel times are summarised below:

Table 6-16: Trip Length Distribution

Trip Length (km)	Percentage
0 – 5 km	14%
5 – 10 km	24%
10 – 15 km	24%
15 – 20 km	17%
20 – 25 km	9%
25 – 30 km	6%
30 – 35 km	3%
35 – 40 km	2%
40 – 45 km	1%
45 – 50 km	0%
>50 km	1%
Total	100%

Table 6-17: Travel Time Distribution

Travel Time	Percentage
0 – 5 min	3%
5 – 10 min	8%
10 – 15 min	8%
15 – 20 min	9%
20 – 25 min	7%
25 – 30 min	15%
30 – 35 min	7%
35 – 40 min	8%
40 – 45 min	10%
45 – 50 min	5%
50 – 55 min	2%
55 – 60 min	10%

Travel Time	Percentage
60 – 120 min	7%
>120 min	2%
Total	100%

From the surveys, the average trip length was calculated as 16.4 km, with a standard deviation of 12.8 km. The average travel time was 37 minutes, with a standard deviation of 24 minutes. The typical travel speed on the network (including the effect of delays at intersections on the journey time) was therefore approximately 27 km/h.

From the surveys, it was evident that many drivers did not really know the length of their respective trips. The trip length distribution should therefore be considered with caution.

Information from the SP surveys indicated longer average trip times of 71 minutes, which appears more realistic taking into account the respective origins and destinations and the current traffic conditions.

6.4 EXISTING TRAFFIC CHARACTERISTICS

The purpose of all traffic survey data was to form a sound basis for traffic modelling of future scenarios. The traffic counts and OD data was thus used to construct base year trip matrices, which could be used to model the impact of future traffic growth, network congestion, changes to the road network and toll plazas associated with the envisaged Toll Road Projects.

It must be considered that the data obtained from the traffic counts were more reliable than that obtained from the OD surveys – *all* traffic was counted at the respective survey locations, while only a *sample* (6% on average) of motorists were interviewed. The OD interview data was therefore used to construct preliminary trip matrices, which were calibrated using the EMME/2 modelling software to fit the more reliable screen line counts at various locations on the road network.

6.4.1 DESCRIPTION OF MARKET SEGMENTS AND ANALYSIS PERIODS

Five different market segments were identified for the purpose of analysis:

- ⇨ Light vehicles (commuter)
- ⇨ Light vehicles (business)
- ⇨ Light vehicles (other purposes)
- ⇨ Taxi and bus

- ⇨ Heavy vehicles

The market segments had to be reasonably homogeneous, and were identified based on the following similarities within each segment:

- ⇨ Similar trip-making and peaking characteristics
- ⇨ Similar value of time
- ⇨ Same toll class and –fare

Different analysis periods were also selected for modelling, based on the trip-making and peaking characteristics and traffic volumes within these periods. Data from the electronic traffic counter on Maroko Road was used to determine the change in peak flow periods between weekdays, Saturdays and Sundays. The following reasonably homogeneous traffic flow periods were identified:

- ⇨ Weekday AM (06:00 – 10:00)
- ⇨ Weekday Off (10:00 – 15:00)
- ⇨ Weekday PM (15:00 – 19:00)
- ⇨ Weekday Night (19:00 – 06:00)
- ⇨ Saturday AM (07:00 – 11:00)
- ⇨ Saturday Off (11:00 – 16:00)
- ⇨ Saturday PM (16:00 – 20:00)
- ⇨ Saturday Night (20:00 – 07:00)
- ⇨ Sunday AM (08:00 – 12:00)
- ⇨ Sunday Off (12:00 – 16:00)
- ⇨ Sunday PM (16:00 – 20:00)
- ⇨ Sunday Night (20:00 – 08:00)

The traffic modelling had to allow for each of the market segments per analysis period, i.e. 60 trip matrices for the base year.

6.4.2 AVERAGE ANNUAL TRAFFIC DEMAND (AADT)

The manually surveyed traffic counts were used to model the Average Daily Traffic (ADT) for each of the survey locations. Periods with no data (Saturday, Sunday and night-time) were modelled with reference to other similar survey locations in the immediate vicinity, and traffic flows profiles from the electronic traffic counting station on Maroko Road. The modelled ADTs for the respective survey locations are shown below:

Table 6-18: Modelled ADT, 2004

Survey Location	Light Other	Taxi	Heavy	All
L1 – Ajah	22,163	8,472	2,381	**33,017**
L2 – Mr Biggs Circle	26,675	8,661	2,116	**37,451**
L3 – Admiralty Way Circle	33,588	9,939	1,840	**45,367**
L4 – Epe Toal Filling Station	38,585	10,156	2,244	**50,985**
L5 – Falomo Bridge	57,377	5,371	2,142	**64,890**
L6 – Ozumba Mbadiwe Rd	20,515	6,684	847	**28,045**
L7 – Ahmadu Bello Bridge	54,784	13,725	2,262	**70,770**
L8 – Adeola Odeku Street	16,369	2,572	287	**19,228**
L9 – Bar Beach Road	24,782	5,201	567	**30,550**

6.4.3 CLASSIFICATION PER VEHICLE CLASS, TRIP PURPOSE AND MARKET SEGMENT

The manual traffic counts were used to determine average hourly traffic volumes per analysis period, for each of the respective market segments. Periods that were not actually counted were modelled with reference to the traffic profiles of adjacent counting stations and the electronic traffic counter on Maroko Road.

The breakdown of light vehicles into Commercial, Business or Other purposes was done with reference to the trip purposes obtained from the OD interviews.

The average hourly traffic volumes across screen lines, for each market segment and per analysis period, are shown below for the weekday, Saturday, and Sunday respectively:

Table 6-19: Average Hourly Traffic Volumes, Weekday, August 2004

Location	Segment	Northbound / Eastbound				Southbound / Westbound			
		AM	Off	PM	Night	AM	Off	PM	Night
L1	Light Comm	122	189	558	0	438	229	302	0
	Light Business	155	334	204	0	205	384	296	0
	Light Other	61	167	82	230	112	121	45	191
	Taxi	242	223	241	76	266	280	358	88
	Heavy	61	88	117	29	63	83	77	21
L2	Light Comm	168	202	471	0	422	185	264	0
	Light Business	231	391	333	0	359	409	247	0
	Light Other	43	175	157	272	190	265	307	231
	Taxi	270	227	265	86	331	264	291	78
	Heavy	71	93	69	21	52	70	95	18
L3	Light Comm	192	279	560	0	732	422	437	0
	Light Business	273	540	300	0	569	564	376	0
	Light Other	44	139	224	278	81	121	267	339
	Taxi	320	287	267	81	386	310	343	97
	Heavy	62	65	56	15	38	65	99	22
L4	Light Comm	247	348	519	0	807	490	522	0
	Light Business	388	684	682	0	297	584	421	0
	Light Other	94	159	185	357	287	278	127	338
	Taxi	328	281	337	90	330	332	382	102
	Heavy	71	86	91	24	46	82	94	20
L5	Light Comm	529	445	1230	0	1228	564	716	0
	Light Business	506	1393	1128	0	1136	1077	618	0
	Light Other	130	231	123	632	238	296	227	544
	Taxi	92	112	83	31	332	249	246	72
	Heavy	40	89	132	24	58	71	50	17
L6	Light Comm	216	110	259	0	328	300	393	0
	Light Business	187	398	283	0	164	457	302	0
	Light Other	42	84	64	163	328	130	96	228
	Taxi	172	155	145	43	302	266	331	81
	Heavy	38	35	32	9	21	28	34	7
L7	Light Comm	754	613	1400	0	750	469	795	0
	Light Business	431	1149	680	0	662	1286	827	0
	Light Other	32	278	180	556	529	519	151	523
	Taxi	545	503	608	161	410	366	406	109
	Heavy	51	87	84	19	87	91	120	24
	Light Comm	183	175	148	0	85	161	342	0

Location	Segment	Northbound / Eastbound				Southbound / Westbound			
		AM	Off	PM	Night	AM	Off	PM	Night
L8	Light Business	221	293	212	0	198	414	405	0
	Light Other	42	89	121	133	44	101	137	199
	Taxi	77	73	62	18	92	95	137	30
	Heavy	13	10	8	2	7	11	16	3
L9	Light Comm	280	155	198	0	142	110	417	0
	Light Business	518	737	698	0	333	613	312	0
	Light Other	63	177	171	278	44	90	97	207
	Taxi	184	164	186	54	184	152	188	54
	Heavy	29	30	17	8	11	18	16	5

Table 6-20: Average Hourly Traffic Volumes, Saturday, August 2004

Location	Segment	Northbound / Eastbound				Southbound / Westbound			
		AM	Off	PM	Night	AM	Off	PM	Night
L1	Light Comm	49	189	246	0	97	122	187	0
	Light Business	238	410	264	0	239	361	234	0
	Light Other	218	434	446	206	219	371	332	195
	Taxi	246	240	261	71	219	305	355	88
	Heavy	65	83	78	21	86	95	56	21
L2	Light Comm	107	91	130	0	122	123	65	0
	Light Business	221	371	146	0	272	356	131	0
	Light Other	267	684	827	245	286	541	718	237
	Taxi	264	244	295	80	278	266	281	86
	Heavy	65	78	43	19	70	78	65	20
L3	Light Comm	71	246	300	0	165	187	334	0
	Light Business	346	532	322	0	406	552	417	0
	Light Other	316	564	545	279	373	567	592	322
	Taxi	333	276	258	87	322	302	359	109
	Heavy	55	53	33	15	49	74	84	20
L4	Light Comm	93	307	388	0	191	217	307	0
	Light Business	453	665	417	0	470	642	384	0
	Light Other	415	704	705	362	432	660	545	333
	Taxi	302	303	327	94	287	342	387	104
	Heavy	62	78	56	20	68	91	70	21
L5	Light Comm	80	402	676	0	130	199	315	0
	Light Business	519	774	730	0	682	837	644	0
	Light Other	334	626	463	389	462	713	587	393

Location	Segment	Northbound / Eastbound				Southbound / Westbound			
		AM	Off	PM	Night	AM	Off	PM	Night
	Taxi	54	90	79	21	203	199	247	62
	Heavy	59	77	71	18	79	108	89	25
L6	Light Comm	24	90	112	0	77	72	153	0
	Light Business	118	194	121	0	189	213	191	0
	Light Other	108	206	204	115	173	219	271	129
	Taxi	127	128	105	40	245	194	245	71
	Heavy	15	29	14	6	17	17	17	6
L7	Light Comm	38	349	527	0	218	282	424	0
	Light Business	303	677	554	0	336	563	380	0
	Light Other	465	646	554	359	380	525	468	309
	Taxi	410	430	446	135	291	293	298	97
	Heavy	25	53	41	11	49	62	51	17
L8	Light Comm	25	84	83	0	35	66	170	0
	Light Business	120	182	89	0	86	195	213	0
	Light Other	109	193	151	99	79	200	302	105
	Taxi	57	59	44	18	75	80	96	25
	Heavy	5	8	3	2	7	8	7	2
L9	Light Comm	50	164	195	0	55	71	157	0
	Light Business	244	356	210	0	135	211	196	0
	Light Other	223	376	354	208	124	217	278	115
	Taxi	130	147	143	49	134	119	152	44
	Heavy	14	19	12	4	11	12	9	3

Table 6-21: Average Hourly Traffic Volumes, Sunday, August 2004

Location	Segment	Northbound / Eastbound				Southbound / Westbound			
		AM	Off	PM	Night	AM	Off	PM	Night
L1	Light Comm	0	21	321	0	4	231	430	0
	Light Business	58	113	116	0	40	124	215	0
	Light Other	414	690	301	168	518	324	0	182
	Taxi	186	208	219	68	197	226	228	75
	Heavy	19	35	24	10	21	31	24	7
L2	Light Comm	31	108	61	0	40	21	59	0
	Light Business	84	103	149	0	100	107	227	0
	Light Other	371	817	736	200	553	644	800	237
	Taxi	226	247	229	79	214	220	229	76
	Heavy	20	24	12	10	27	24	13	8

Location	Segment	Northbound / Eastbound				Southbound / Westbound			
		AM	Off	PM	Night	AM	Off	PM	Night
L3	Light Comm	27	118	185	0	52	155	145	0
	Light Business	124	275	206	0	177	263	406	0
	Light Other	448	806	631	220	720	536	1029	334
	Taxi	302	286	208	83	238	231	291	97
	Heavy	16	16	9	9	20	22	15	7
L4	Light Comm	66	120	93	0	58	124	181	0
	Light Business	121	96	103	0	135	185	141	0
	Light Other	565	1108	1000	261	731	817	1128	312
	Taxi	220	242	211	78	222	215	209	71
	Heavy	28	27	16	8	34	26	13	7
L5	Light Comm	37	107	264	0	48	141	100	0
	Light Business	169	248	293	0	164	240	278	0
	Light Other	609	729	897	294	670	490	707	287
	Taxi	61	46	55	18	149	132	134	54
	Heavy	8	26	14	5	28	19	8	7
L6	Light Comm	8	52	62	0	13	73	41	0
	Light Business	55	169	147	0	65	266	267	0
	Light Other	323	308	312	133	415	302	483	184
	Taxi	101	98	99	37	186	184	196	66
	Heavy	20	13	7	4	11	12	6	4
L7	Light Comm	14	154	218	0	100	120	232	0
	Light Business	365	416	435	0	344	431	418	0
	Light Other	414	506	580	294	354	562	488	270
	Taxi	271	305	315	103	185	215	225	74
	Heavy	11	15	10	5	30	27	18	11
L8	Light Comm	11	29	44	0	10	65	56	0
	Light Business	48	67	49	0	36	110	158	0
	Light Other	174	197	151	89	145	224	400	86
	Taxi	38	42	31	13	50	60	73	18
	Heavy	2	2	1	2	5	3	3	1
L9	Light Comm	22	57	104	0	15	66	52	0
	Light Business	98	132	116	0	53	112	145	0
	Light Other	354	386	355	183	216	228	367	96
	Taxi	84	105	101	37	87	86	115	33
	Heavy	5	5	2	3	9	4	3	1

In addition, screen line counts were also obtained for the three bridges connecting Lagos Island with the Mainland (Eco Bridge, Carter Bridge and the 3rd Mainland Bridge), various positions on Lagos and Ikoyi Island as well as two locations on the Epe expressway east of Ajah town. The traffic volumes for these locations were modelled from counts conducted in November 2003 for the purpose of the Pre-Feasibility Study.

It should be noted that the traffic surveys in August 2004 were conducted during the school holidays. A direct comparison of the traffic volumes across Falomo Bridge and Ahmadu Bello Bridge indicated that the traffic volumes in August 2004 were approximately 15% lower than in November 2003 (non-holiday period). For the purpose of matrix calibration, the screen line traffic volumes modelled from the November 2003 counts were therefore reduced by 15% to match the observed traffic in August 2004. The additional screen line traffic volumes are attached as Annexure GDW4.

6.4.4 ORIGIN-DESTINATION INFORMATION PER MARKET SEGMENT

Origin-destination data was used to develop trip distribution matrices for each of the nine survey locations, for light vehicles (commuter, business and other), taxis and buses and heavy vehicles, for each of the traffic analysis periods. For locations where data was not available for all of the periods, the matrices for other relevant periods were used, e.g. the off-peak matrices were used to distribute night traffic since no OD-interviews were conducted at night. The deliverable of this exercise was distribution matrices (in percentages) – 60 matrices (i.e. for each market segment per analysis period) for each of the nine survey locations, separated per direction of travel.

The respective distribution matrices were multiplied with the corresponding traffic volumes for the specific market segments and analysis periods at the respective survey locations, to obtain trip matrices for each survey location. Nine trip matrices were therefore available for each analysis scenario (e.g. Light commuter traffic, AM peak period) – one matrix per survey location. However, since these survey locations were scattered across the road network, the traffic volumes for all OD-pairs could not be obtained from each matrix with the same level of accuracy. The matrices that describe a specific OD-pair best were thus used to eventually produce a single OD trip matrix for the entire portion of Lagos as covered by the OD zones.

The result was 60 trip matrices showing the distribution of vehicle trips, per market segment and analysis period, over the 12 OD-zones. It should be considered that these matrices yielded reasonable traffic volumes on road links once assigned onto the road network, but these link volumes did not correspond exactly with the screen line counts from which the matrices were developed. This is because the trip matrices for different survey locations, were developed from different screen line counts and different sets of OD data (and only a *sample* of motorists were interviewed), that were combined to form a single trip matrix per scenario. These unadjusted matrices were therefore calibrated using the EMME/2 software to represent the screen line counts at the 9 survey locations (as well as a number of other screen lines on Lagos and Ikoyi Island) as accurately as possible.

The manipulation of the matrices is discussed in the following sections.

6.5 TOLL STRATEGY

The toll strategy for the Lekki Corridor and the Lekki Corridor with the Southern Bypass is described in Section 4.5.

6.6 TRAFFIC MODELLING

6.6.1 DESCRIPTION OF TRAFFIC MODEL

The EMME/2 traffic demand modelling software encompasses an interactive-graphic state-of-the-art multimodal urban transportation planning system. It offers the planner a complete and comprehensive set of tools for demand modelling, multimodal network modelling and analysis and for the implementation of evaluation procedures. EMME/2 is also a decision support system, which provides uniform and efficient data handling procedures, including input data validation. Its data bank is structured to permit the simultaneous description, analysis and comparison of several contemplated scenarios.

6.6.2 DESCRIPTION OF NETWORK AND ZONE SYSTEM

6.6.2.1 General description

The planned toll road network included in the transportation model is summarized in Table 6-22.

Table 6-22: Potential Toll Road Network for Evaluation

FACILITY	FROM	TO	LENGTH	NETWORK ALTERNATIVES
Epe Expressway	Falomo Bridge	4th Mainland Bridge Link	20.0km	Upgrade to six-lane urban / rural arterial
	4th Mainland Bridge Link	Eleko Beach Turn-off	27.5km	Upgrade to appropriate rural arterial with four-lane cross-section
Coastal Freeway	Akin Adesola	Lekki Link	6.5km	New four-lane freeway New six-lane freeway
	Lekki Link	4th Mainland Link	13.5km	New two-lane rural highway New four-lane freeway

FACILITY	FROM	TO	LENGTH	NETWORK ALTERNATIVES
	4th Mainland Link	Eleko Beach	27.5km	New two-lane rural highway New four-lane freeway
Links	Admiralty Link		0.9km	New four-lane urban arterial
	Lekki Link		0.8km	New four-lane urban arterial
	Gbari Link		1.1km	New two-lane urban street New four-lane urban street
	Chevron Link		1.5km	New two-lane urban street New four-lane urban street
	4th Mainland Link		5.1km	New two-lane urban street New four-lane urban street
	Santiago Link		4.4km	New two-lane urban street New four-lane urban street
	New Town Link 1		3.1km	New two-lane urban street New four-lane urban street
	New Town Link 2		3.3km	New two-lane urban street New four-lane urban street
	New Town Link 3		2.9km	New two-lane urban street New four-lane urban street
	Eleko Beach Link		3.5km	New two-lane urban street New four-lane urban street
Southern Bypass	New directionals		0.8km	New direct link between eastern Ring Road and Southern Bypass
	Ozumba Mbadiwe	Akin Adesola	2.6km	New four-lane urban freeway New six-lane urban freeway

6.6.2.2 Traffic Zones

For building transportation models, all urban areas are subdivided into homogeneous traffic zones. All the data related to socio-economic variables and travel demand is captured in matrices by traffic zone. The Coastal Road study area was subdivided into the 12 traffic zones described below (Refer to Figure 6-4):

- ⇨ Zone 1: The Mainland Zone represents the areas on the mainland of Lagos City and the area beyond. This area is densely populated with a variety of mixed land uses. Very high levels of roadside friction exist in some parts even on major routes. Eko Bridge, New Cater Bridge and Third Mainland Bridge provide access to this area from the south.

- ⇨ Zone 2: Lagos Island Zone is the area west of Ikoyi Road and surrounded by Lagos Harbour in the south and Lagos Lagoon in the north. This area represents a business district, which is densely populated with about 100% of the area developed. Ikoyi Road and New Marina Road forms a ring road system around this area. Internal roads do not have enough capacity to handle current demand. Infringement of traders on road reserves is extremely high in this area.

- Zone 3: Obalende Zone is the area east of Ikoyi Road, west of Kingsway Road and surrounded by Lagos Lagoon in the north and Five Cowrie Creek to the south. This area is characterized by a business zone along Awolowo Road in the south with mixed residential and business land use in other areas. Internal roads in this area are also under pressure due to design standards and weak connectivity.

- Zone 4: Ikoyi Island Zone is located east of Kingsway Road and is surrounded by Five Cowrie Creek in the south and east with Lagos lagoon to the north. Kingsway Road provides the only access to this area. This is mainly a residential area with large stands with a low population density. A few home offices exist in this area. Internal roads are of higher standard with wider road reserves and low level of roadside friction.

- Zone 5: Victoria Island Zone is located west of Akin Adesola Street, south of Five Cowrie Creek and east of Lagos Harbour. Ahmadu Bello Bridge in the west and Kingsway Bridge (Falomo Bridge) to the east provides access to this area from the north. This area is also a mixed land use area with businesses along major roads and residential homes on minor roads. Roadside friction along major roads that provides good connectivity to lower order roads is high.

- Zone 6: Victoria Island Annex is located east of Akin Adesola Street and west of a north-south screen line through Admiralty Circle. This area is about 55% developed with most of the development to the west. This area has a strong business zone on the western and northern side. A smaller residential zone is located to the southwest. Roadside friction in the business area is high due to roadside parking. Parking in general is a problem in this area. Kingsway Bridge provides access to the north, Epe Express way provides access to the east and Ahmadu Bello Way and Ozumba Mbadiwe Avenue to the west.

- Zone 7: This zone is located to the east of Zone 6 and west of a north-south screen line through Mr Biggs Circle. This area is about 30% developed with a mixed land use component. Access to the area is provided by traffic circles of Epe Expressway.

⇨ Zone 8: This zone is located to the east of Zone 7 and west of Ajha Town. The zone is about 15% developed. Most of the development is located to the north of Epe Expressway. Epe Expressway is the only east west connection to adjacent zones.

⇨ Zone 9: This zone lay to the east of Zone 8. The total area of this zone is substantially larger that the previous zones. Ajha Town lay on the western border of this zone. This town is the largest business centre in the area with a medium dense residential area around it. The total area is about 5% developed.

⇨ Zone 10, 11 and 12: These zones are virtually undeveloped rural areas. Some housing estates with businesses are planned or under construction in these areas. Eleko Beach is located in Zone 12, which is a popular weekend retreat for people from Lagos.

Epe Expressway is the only connection between Zones 6, 7, 8, 9, 10, 11 and 12. Most of the businesses from Zone 7 eastwards is located next to this road. Infringement of the road reserve is common.

Figure 6-5 and Figure 6-6 depict the EMME/2 centroids, which represents each traffic zone, together with the area that each zone encapsulates. In the modelling process, all trips produced by or attracted to a specific traffic zone either originate or terminate at that zone's centroid.

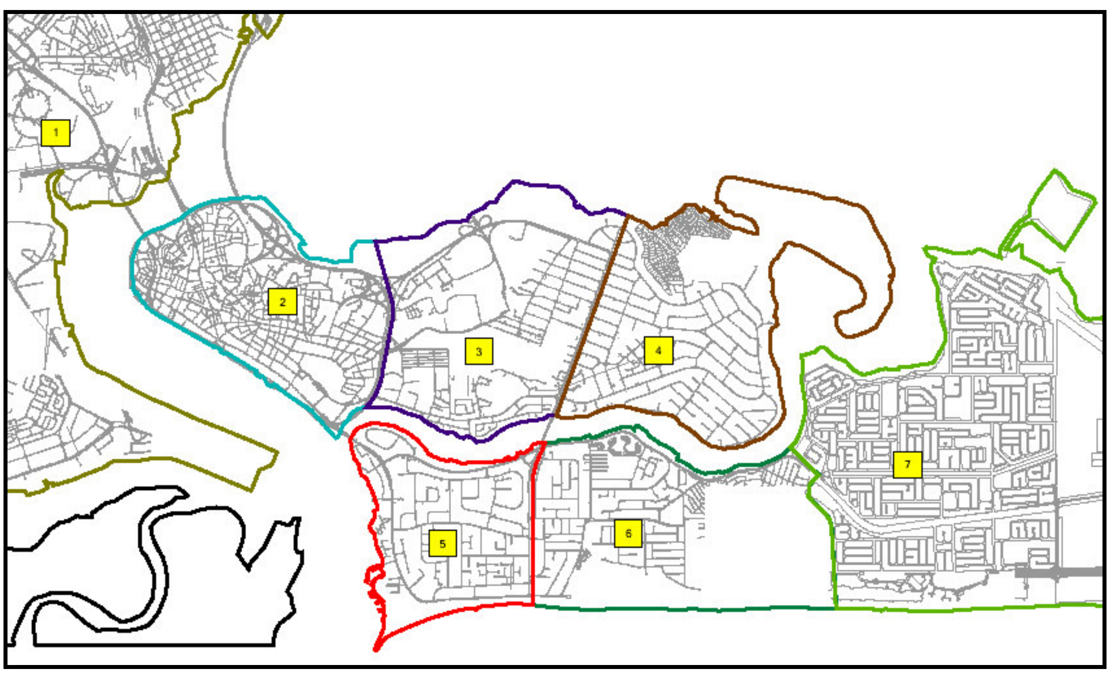


Figure 6-5: EMME/2 Traffic Zones (1 to 7)

Figure 6-6: EMME/2 Traffic Zones (8 to 11)

6.6.2.3 Network Links and Centroid Connectors

The EMME/2 base network consists of nodes and links. The nodes are divided into centroids and regular nodes. As described earlier, a centroid is a node that is associated with a specific traffic zone. A regular node may correspond to an intersection, a transit stop, etc. A link is a directional connection between two nodes. A link that connects a centroid to a regular node is called a connector link or a centroid connector (refer to Figure 6-7). Each node contains information related to turn restrictions and turn penalties, whereas each directional link contains information related to mode, length, number of lanes, road type and volume-delay function.

The 2004 base-year network consist of a total of 275 regular nodes, 730 directional links and a total link length of 392 km. In comparison, the 2037 future year scenario consists of a total of 337 regular nodes, 870 directional links and a total link length of 568 km.

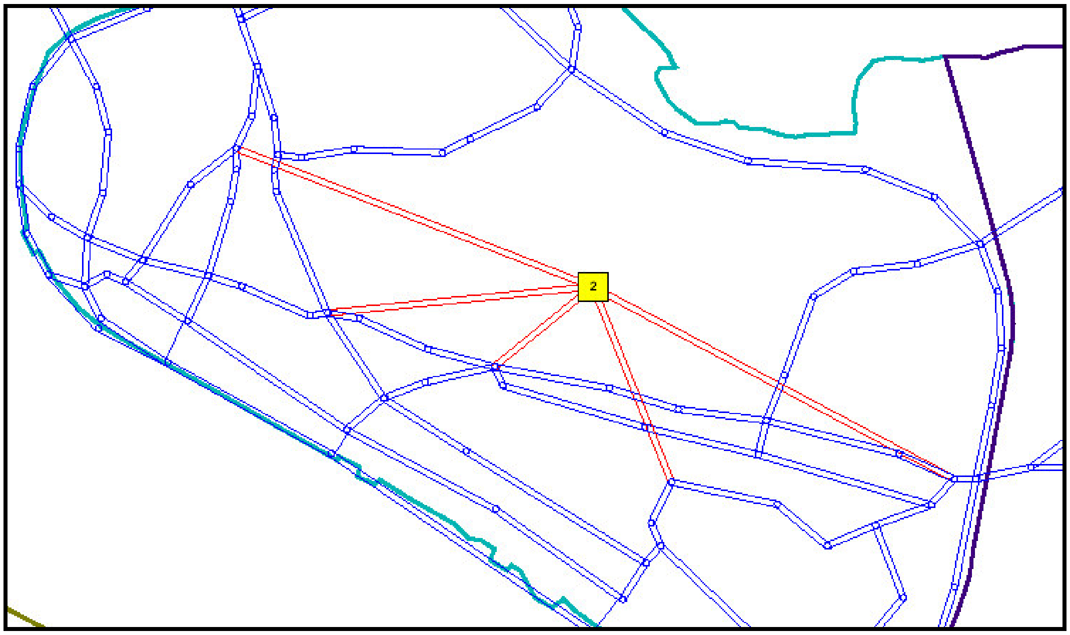


Figure 6-7: Example of EMME/2 Road Network

6.6.2.4 Turn Penalties and Turn Restrictions

The regular nodes in the EMME/2 traffic model were coded according to current conditions at the intersections / interchanges on the existing road network. Turn restrictions were defined at nodes where certain movements are prohibited. An example of turn restrictions defined at the Ring Road / Awolowo Road interchange (prohibited turns indicated in red) are given in Figure 6-8.

6.6.2.5 Network Classification

Roads in the study area were categorized into road classes according to their functional class, design standard, capacity and free flow speed. Six road classes where identified. Table 6-23 shows the roads in the 2004 base-year model network and their road class. The average free flow speeds were estimated from the travel time surveys. It should be noted that adjustments were made to links on the road network (i.e. number of lanes, classification, etc.) for the future scenarios as required (based on the capacity analysis results after each assignment).

An example of the EMME/2 network classification for the 2004 base-year is given in Figure 6-9.

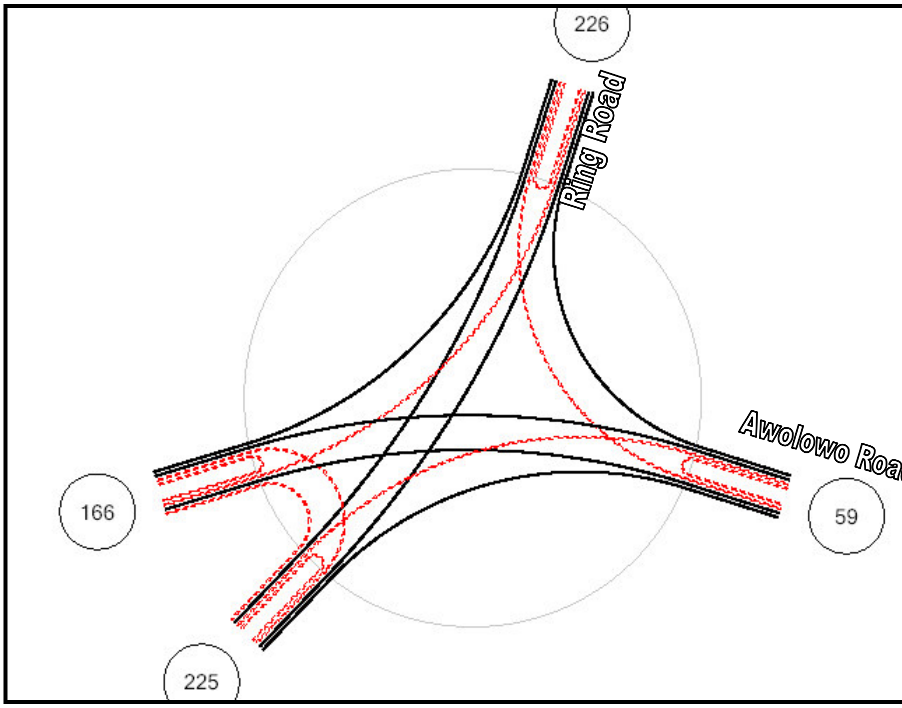


Figure 6-8: Turn Restrictions (Ring Road / Awolowo Road Iterchange)

Table 6-23: Network Classification

Road Class	Description	Free Flow Speed (km/h)	Capacity (PCU/h/lane)	Roads
1	Streets (Urban)	40	575	All local streets
2	Undivided roads with 2 or 4 lanes	45	765	Awolowo Road
3	Low Standard Dual carriageway road with 4 or 6 lanes (Urban)	50	1010	Ozumba Mbadiwe Avenue Maroko Road New Cater Bridge
4	High Standard Dual carriageway road with 4 or 6 lanes (Urban)	55	1020	Eko Bridge Adeniyi Adele Road Osborne Road Kingway Road Akin Adesola Street Ahmadu Bello Road
5	Dual carriageway road with 4 or 6 lanes (Rural and Sub-Urban)	65	1200	Epe Express Way
6	Freeway with 6 or 8 lanes	80	1800	Third Mainland Bridge Ikoyi Road New Marina Road

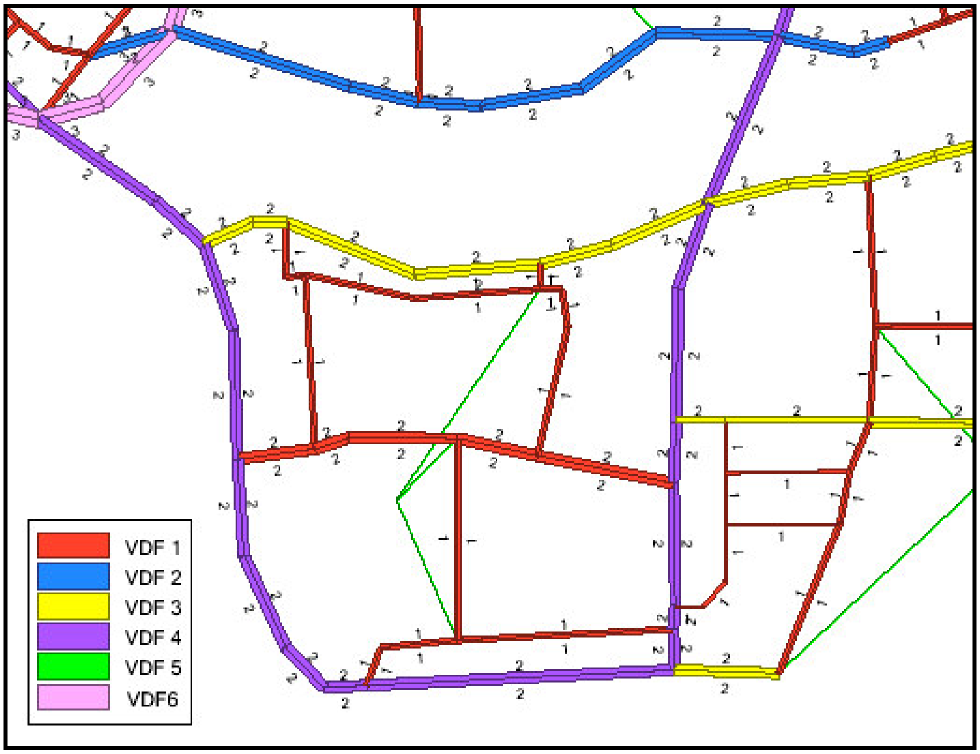


Figure 6-9: Network Classification (Road Class and Number of Lanes)

6.6.2.6 Volume-Delay Functions (VDF's)

▲ **VDF's excluding vehicle operating costs (VOC)**

Volume delay functions specify the relationship between the travel time on each link of the model network, and other attributes of the link (such as the volume on it). Volume-delay functions may use units of travel time only or generalized time units, which may contain tolls or other relevant costs, converted to minutes (through application of a "value-of-time" constant). A specific volume-delay function is specified for each link.

In the development of volume-delay functions for Lagos, travel times and distances between nodes from the travel time surveys were aggregated to give route performance data, which were then compared and arranged according to available hourly traffic flow data for each road class. From this information, a number of volume-delay functions were developed based on the following function:

$$Travel\ Time\ (\min) = \frac{length * 60}{FFS}\left(1 + f_1\left(\frac{volume}{lanes * C_1 * f_2}\right)^{f_3}\right) \qquad \text{.....................(1)}$$

where: length = assigned length of link (km)

volume = assigned traffic volume on link (PCU/h)

lanes = number of lanes on link

FFS = Free Flow Speed (km/h)

C_1 = Capacity (PCU/h/lane)

f_1 , f_2 , f_3 = constants

Table 6-24 is a summary of the values used in the volume-delay functions for the different road classes in the EMME/2 network. Figure 6-10 depicts the volume-delay functions by road class (excluding vehicle-operating costs).

Table 6-24: Volume-Delay Function Attributes

Attribute	Road Class					
	1	2	3	4	5	6
	Urban Street	Undivided Roads	Urban Dual Low Standard	Urban Dual High Standard	K-route type	Freeway
FFS	40	45	50	55	65	80
C1	575	765	1010	1020	1200	1800
f1	1.16	0.74	0.6	0.45	0.3	0.5
f2	0.85	0.75	0.71	0.66	0.6	0.69
f3	4.8	4.8	4.8	4.8	5.2	6.5

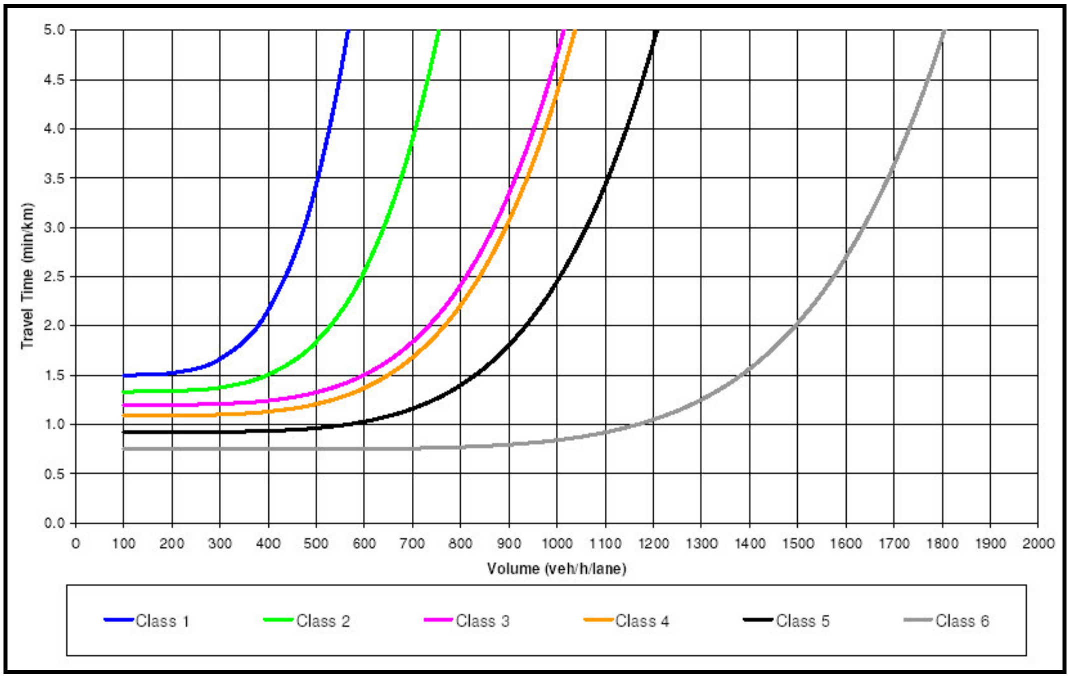


Figure 6-10: Volume-Delay Functions (excluding vehicle operating costs)

▲ <u>**VDF's including vehicle operating costs (VOC)**</u>

It should be noted that the equilibrium traffic assignment assumes that each road user chooses the route that he perceives the best; if there is a shorter route than the one that he using, he will choose it. It is believed that the road user not only considers time of travel when evaluating a particular route, but also cost of travel, and more specifically *perceived* cost of travel (i.e. fuel cost). It was therefore decided to include vehicle-operating cost (fuel consumption) in the volume-delay functions. The following fuel consumption equation, linking operating speed (km/h) to fuel consumption (l/100km), was utilised:

$$\text{FTS} = 0{,}01524V^2 - 1{,}7010V + \frac{1467{,}6}{V} + 100{,}6 \quad \text{..............................(2)}$$

Where FTS = Fuel Consumption (l/1000km)

V = Speed (km/h)

Equation (2) can however be approximated by the following power function, which yields similar results for speeds between 5km/h and 100km/h:

$$FTS_{cars} = 638.6V^{-0.4562} \quad \text{...(3)}$$

Through the application of a value of time (VOT) cost of 100N/h and a fuel cost of 50N/l, the fuel consumption cost can be written as follows:

$$FTS_{cars} = 2.95908 * L^{0.5438} * timau^{0.4562} \quad \text{.......................................(4)}$$

Where L = Link length (km)

timau = Auto travel time on link (min)

The relationship between travel time (min/km) and vehicle operating cost (min/km) as a function of operating speed (km/h) is given in Figure 6-11 below:

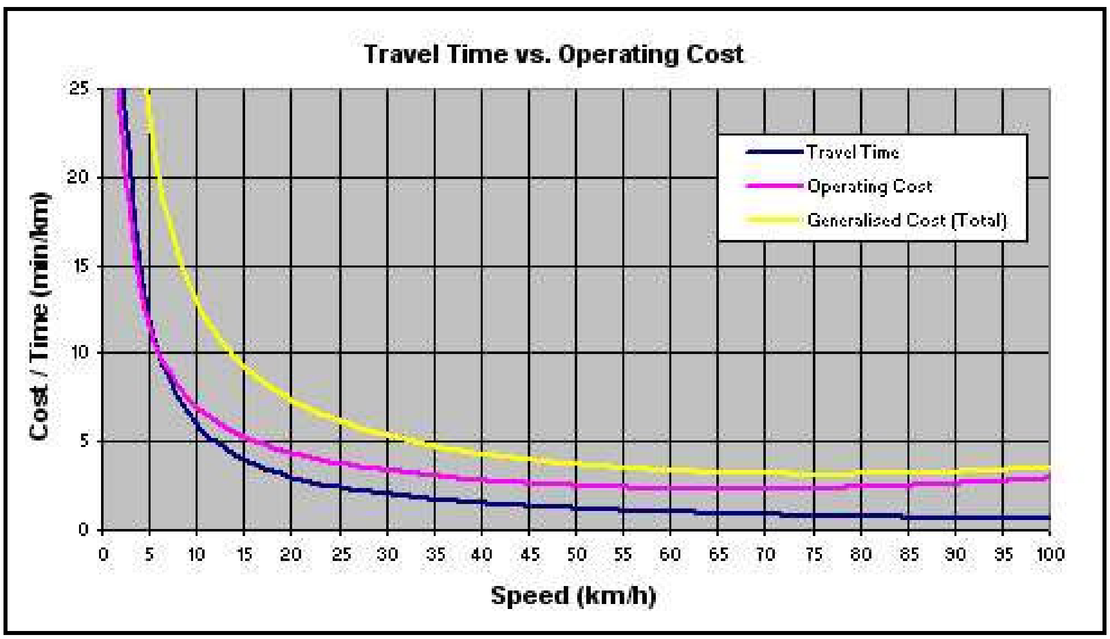


Figure 6-11: Travel Time vs. Vehicle Operating Cost

The auto travel time on each link (timau) in Equation (4) can be substituted by the volume-delay function (VDF) for each link. The vehicle operating cost was thus taken into consideration during the equilibrium assignment in the following way:

Timau (VDF2) = VDF1 (min) + Operating Cost (min)

Where Operating Cost = f(Link length, VDF1)

Figure 6-12 depicts the volume-delay functions by road class (including vehicle-operating costs). These volume-delay functions were utilised during the equilibrium assignment.

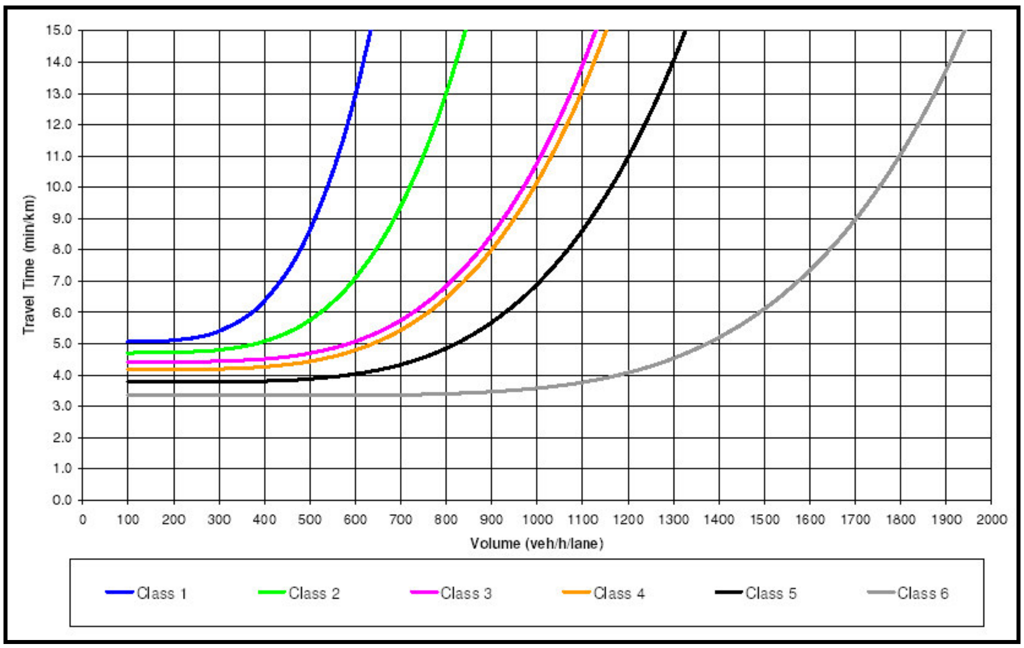


Figure 6-12: Volume-Delay Functions (including vehicle operating costs)

6.6.3 DESCRIPTION OF MODELLING PROCEDURE

6.6.3.1 Step 1: Trip Generation

Trip generation models are used to estimate the total number of trips emanating from a traffic zone (productions) and the total number of trips attracted to each traffic zone (attractions). For the 2004 base year, the total number of vehicle trip productions and attractions by traffic zone were obtained directly from the adjusted O-D matrices. It should be noted that these productions and attractions refer to inter-zonal trip ends only, i.e. trips originating and terminating within the same traffic zone were not modelled. Appropriate inter-zonal traffic growth factors were applied to obtain vehicle trip productions and attractions for the future year scenarios.

6.6.3.2 Step 2: Modal Choice

The issue of mode choice is an important element in transport planning and policy making. Numerous factors influence the choice of transport mode, of which the following are examples:

- ⇨ Trip maker characteristics (car ownership, household structure, income, etc.);
- ⇨ Journey characteristics (trip purpose, time of day, etc.);
- ⇨ Transport facility characteristics (travel time, monetary costs, parking, convenience, reliability, security, etc.)

For the purpose of this study, the adjusted O-D matrices were each split into five separate matrices (according to the five market segments) with the help of the classified traffic counts and O-D surveys. The same modal split percentages were applied to the future year scenario production and attraction matrices.

6.6.3.3 Step 3: Trip Distribution

Trip distribution entails the dispersal of trips produced / attracted by each traffic zone between the various O-D pairs, which gives the modeller an idea of the pattern of trip making within the study area. As described earlier, preliminary 2004 base year matrices (by market segment and analysis period) were developed directly from the O-D surveys and traffic counts. These matrices were then adjusted to represent the screen line counts at the nine survey locations as accurately as possible.

Although these adjusted matrices are a good representation of the pattern of trip making for the 2004 base year, this pattern will invariably change in future with certain traffic zones within the study area developing at a higher rate than others. This necessitated the development of a trip distribution model applicable to the 2004 base year as well as each of the future year scenarios. For the purposes of this study, a Gravity Distribution Model was developed based on Newton's law of gravitation, which states the following:

> *"…The force of attraction between two bodies is directly proportional to the product of the masses of the two bodies and inversely proportional to the square of the distance between them."* [ref 2]

The applied trip distribution model requires as input the following:

- ⇨ Production matrix (total number of vehicle trips produced by traffic zone);
- ⇨ Attraction matrix (total number of vehicle trips attracted by traffic zone);
- ⇨ "Deterrence" matrix.

The above matrices are used during a two-dimensional balancing procedure in EMME/2 to calculate "balanced" O-D matrices by market segment and analysis period.

6.6.3.4 Step 4: Trip Assignment

To adequately provide for the impact of different vehicle types on congestion, each of the assigned modes had to be defined in terms of Equivalent Passenger Car Units (PCUs). PCU factors are used to convert a traffic stream composed of a mix of different vehicles into an equivalent traffic stream composed of passenger cars. Each vehicle within the traffic stream is in effect replaced by a fraction of a passenger car or by several passenger cars. A summary of the PCU factors used (ref 2) in this study is given in Table 6-25 below:

Table 6-25: Passenger Car Unit (PCU) Factors

Market Segment	EMME/2 Mode	PCU Factor
Light vehicles (Business)	Car	1.0
Light vehicles (Commuter)	Car	1.0
Light vehicles (Other purposes)	Car	1.0
Buses and Taxi's	Bus	1.56 (1)
Heavy vehicles	Heavy	3.5

*Note 1: Bus / Taxi PCU Factor = 0.2*1.2(Taxi) + 0.8*3.0(Bus)*

A multi-class equilibrium (capacity constrained) traffic assignment was performed during which the linear approximation method was used to assign the five balanced market segment matrices simultaneously to the model network based on the following assumption:

"Each traveller chooses the path (or route) perceived as being the best; if there is a shorter path than the one being used, the traveller will choose it. At the equilibrium, no one can improve their travel time by changing paths." (ref 3)

6.6.4 CALIBRATION OF MODEL

The calibration of the 2004 base-year model was achieved through the adjustment of the preliminary O-D demand matrices to reflect the observed average travel speeds and traffic volumes as closely as possible after assignment. The matrix adjustment procedure is described below:

6.6.4.1 The Gradient Approach

In almost all transportation planning applications, the input data, which is the most difficult and expensive to obtain, is the origin-destination demand matrix. Since the demand data cannot be observed directly, it must be collected by carrying out elaborate and expensive surveys, involving home- or road-based interviews or complicated number plate tagging schemes. By contrast, observed link volumes can be obtained easily and with reasonable precision by simply counting the traffic at certain countpost links, either manually or automatically, using mechanical or inductive counting devices. A considerable amount of research has been carried out to investigate the possibility of estimating or improving an origin-destination demand matrix with observed volumes on the links of the considered network.

A matrix adjustment macro was utilised in which the steepest descent property of the gradient method (Heinz Spiess, May 1990 [(1)]) was used to adjust the preliminary O-D matrices to represent the screen line counts as accurately as possible.

6.6.4.2 Adjustment Procedure

The preliminary 2004 base year O-D matrices were adjusted in the following steps:

- ⇨ The five preliminary market segment matrices were assigned (for each analysis period) to the model network with a multi-class equilibrium traffic assignment;
- ⇨ Traffic volumes obtained from the assignment results were compared to the classified traffic counts at each of the 9 survey locations;
- ⇨ Market segment matrices where the comparison yielded a coefficient of determination (R^2) below 0.8 were adjusted consecutively with the matrix adjustment macro.
- ⇨ The number of iterations ("gradient steps") was kept as low as possible to ensure minimum adjustment to the O-D matrices, while achieving the best possible improvement.

6.6.4.3 Adjustment Results

The O-D Matrix adjustment results are summarised in Table 6-26 through Table 6-28.

Table 6-26: Weekday O-D Matrix Adjustment Results

Analysis Period (Hour)	Market Segment	Preliminary O-D Matrices		Adjusted O-D Matrices		
		Volume (PCU's)	Initial R^2	Volume (PCU's)	Gradient Steps	Final R^2
Weekday AM	Light Business	9,376	0.71	8,450	1	0.85
	Light Commuter	8,559	0.71	8,900	0	0.85
	Light Other	3,150	0.62	2,746	2	0.84
	Bus / Taxi	25,893	0.63	16,990	2	0.89
	Heavy	3,516	0.84	3,686	0	0.86
	Total	**50,494**	**0.75**	**40,772**	**N/A**	**0.89**
Weekday Off	Light Business	10,124	0.77	10,278	1	0.83
	Light Commuter	4,820	0.75	4,642	1	0.84
	Light Other	3,150	0.73	2,957	1	0.80
	Bus / Taxi	15,765	0.77	13,537	1	0.84
	Heavy	2,684	0.86	2,684	0	0.88
	Total	**36,544**	**0.84**	**34,098**	**N/A**	**0.88**
Weekday PM	Light Business	8,113	0.85	8,113	0	0.85
	Light Commuter	8,469	0.86	8,469	0	0.86
	Light Other	2,485	0.82	2,485	0	0.82
	Bus / Taxi	13,421	0.92	13,421	0	0.92
	Heavy	3,998	0.91	3,998	0	0.91
	Total	**36,486**	**0.90**	**36,486**	**N/A**	**0.90**
Weekday Night	Light Business	0	N/A	0	0	N/A
	Light Commuter	0	N/A	0	0	N/A
	Light Other	4,406	0.66	4,991	3	0.82
	Bus / Taxi	5,677	0.79	5,677	0	0.78
	Heavy	906	0.86	906	0	0.86
	Total	**10,989**	**0.74**	**11,574**	**N/A**	**0.84**

Table 6-27: Saturday O-D Matrix Adjustment Results

Analysis Period (Hour)	Market Segment	Preliminary O-D Matrices		Adjusted O-D Matrices		
		Volume (PCU's)	Initial R^2	Volume (PCU's)	Gradient Steps	Final R^2
Saturday AM	Light Business	4,460	0.67	3,812	2	0.81
	Light Commuter	1,214	0.67	1,214	0	0.64
	Light Other	3,813	0.69	3,311	2	0.80
	Bus / Taxi	11,613	0.68	11,613	0	0.66

Analysis Period (Hour)	Market Segment	Preliminary O-D Matrices		Adjusted O-D Matrices		
		Volume (PCU's)	Initial R^2	Volume (PCU's)	Gradient Steps	Final R^2
	Heavy	1,648	0.75	1,648	0	0.75
	Total	**22,748**	**0.79**	**21,598**	**N/A**	**0.85**
Saturday Off	Light Business	6,017	0.80	5,929	1	0.87
	Light Commuter	2,228	0.78	2,228	0	0.77
	Light Other	5,692	0.78	5,771	1	0.83
	Bus / Taxi	9,579	0.80	9,579	0	0.80
	Heavy	2,279	0.78	2,279	0	0.77
	Total	**25,795**	**0.87**	**25,786**	**N/A**	**0.89**
Saturday PM	Light Business	4,361	0.86	4,361	0	0.86
	Light Commuter	3,442	0.85	3,442	0	0.85
	Light Other	5,928	0.85	5,928	0	0.85
	Bus / Taxi	8,492	0.81	8,492	0	0.81
	Heavy	2,247	0.82	2,247	0	0.82
	Total	**24,471**	**0.88**	**24,471**	**N/A**	**0.88**
Saturday Night	Light Business	0	N/A	0	0	N/A
	Light Commuter	0	N/A	0	0	N/A
	Light Other	2,670	0.72	2,901	3	0.83
	Bus / Taxi	2,969	0.77	2,969	0	0.79
	Heavy	692	0.80	692	0	0.80
	Total	**6,332**	**0.79**	**6,562**	**N/A**	**0.84**

Table 6-28: Sunday O-D Matrix Adjustment Results

Analysis Period (Hour)	Market Segment	Preliminary O-D Matrices		Adjusted O-D Matrices		
		Volume (PCU's)	Initial R^2	Volume (PCU's)	Gradient Steps	Final R^2
Sunday AM	Light Business	1,486	0.70	1,590	3	0.90
	Light Commuter	360	0.74	360	0	0.71
	Light Other	6,420	0.72	5,812	2	0.83
	Bus / Taxi	8,159	0.74	7,681	3	0.78
	Heavy	649	0.79	649	0	0.78
	Total	**17,074**	**0.80**	**16,092**	**N/A**	**0.86**
Sunday Off	Light Business	2,088	0.70	2,185	3	0.86
	Light Commuter	1,394	0.61	1,394	0	0.60
	Light Other	5,551	0.75	5,790	2	0.90
	Bus / Taxi	6,284	0.79	5,768	1	0.81

Analysis Period (Hour)	Market Segment	Preliminary O-D Matrices		Adjusted O-D Matrices		
		Volume (PCU's)	Initial R^2	Volume (PCU's)	Gradient Steps	Final R^2
	Heavy	912	0.75	912	0	0.75
	Total	**16,228**	**0.82**	**16,049**	**N/A**	**0.90**
Sunday PM	Light Business	2,606	0.72	2,705	3	0.84
	Light Commuter	1,896	0.77	2,054	2	0.87
	Light Other	7,130	0.82	7,130	0	0.82
	Bus / Taxi	5,986	0.82	5,986	0	0.82
	Heavy	564	0.75	564	0	0.75
	Total	**18,181**	**0.85**	**18,439**	**N/A**	**0.87**
Sunday Night	Light Business	0	N/A	0	0	N/A
	Light Commuter	0	N/A	0	0	N/A
	Light Other	2,420	0.76	2,581	3	0.84
	Bus / Taxi	2,273	0.77	2,273	0	0.78
	Heavy	428	0.66	428	0	0.67
	Total	**5,121**	**0.80**	**5,282**	**N/A**	**0.82**

It should again be noted that the matrices were developed from traffic information gathered during August 2004, i.e. the school holidays. However, in order to model the distribution of traffic over the road network and consequently the link traffic volumes on an annual basis, a correction factor had to be introduced to convert the average hourly trip matrices for August to average hourly trip matrices applicable to a year.

As mentioned, the 12-hour weekday traffic volumes across Five Cowry Creek was approximately 15% lower in August 2004 than in November 2003. However, the difference between the electronic traffic counts on Maroko Road in August 2004 (school holiday) and October 2004 (non school holiday) was significantly less. It was therefore concluded that the mentioned 15% difference in traffic applies mostly to the weekday daytime traffic volumes that are most affected by school holidays, and not for other analysis periods (nights and week-ends). Following this approach, the total holiday traffic (as surveyed in August 2004) over a 7-day period was determined to be in the order of 10% lower than the non-holiday period, which appears to be very realistic.

It was assumed that low traffic flows are experienced for a total of 3 months out of a year due to holidays. The adjusted trip matrices for the Weekday AM, Weekday Off-Peak and Weekday PM analysis periods were thus increased by a correction factor to allow for non-holiday months, that was calculated as follows:

Correction factor = (100% x 3/12 year) + (115% x 9/12 year)

= 111.25%

= 1.1125

This correction factor was not applied to the Weekday nighttime and weekend matrices.

6.6.5 MODELLING OF FUTURE DEMAND

6.6.5.1 Trip Generation

The number of trips produced by and attracted to each traffic zone for each future year scenario was estimated by developing appropriate inter-zonal traffic growth factors. These factors were derived from forecasted growth in GDP, i.e. representing growth in attractions, and forecasted growth in the population, i.e. representing growth in productions. Higher growth rates were used in underdeveloped zones compared to the developed zones. These rates were assumed to change over time as more development takes place, and it was assumed that zones closer to the Islands would develop first. It furthermore represents the realistic growth scenario.

Table 6-29: Expected Average Growth Per Annum in Productions & Attractions (from 2004 base-year)

Zones	2007		2012		2022		2037	
	% Growth In Productions	% Growth In Attractions	% Growth In Productions	% Growth In Attractions	% Growth In Productions	% Growth In Attractions	% Growth In Productions	% Growth In Attractions-
1	2.5%	1.5%	2.5%	1.5%	2.5%	1.5%	2.5%	1.5%
2	2.5%	5.0%	2.5%	5.0%	2.5%	5.0%	2.5%	5.0%
3	3.0%	5.0%	2.7%	5.0%	2.6%	5.0%	2.5%	5.0%
4	4.0%	5.0%	3.1%	5.0%	2.7%	5.0%	2.6%	5.0%
5	3.0%	5.0%	2.7%	5.0%	2.6%	5.0%	2.5%	5.0%
6	8.1%	5.0%	5.2%	5.0%	3.7%	5.0%	3.1%	5.0%
7	8.1%	2.5%	7.4%	2.5%	4.9%	2.5%	3.8%	2.5%
8	8.1%	2.5%	7.4%	2.5%	6.3%	2.5%	4.6%	2.5%
9	8.1%	2.5%	7.4%	2.5%	6.6%	2.5%	4.7%	2.5%
10	8.1%	2.5%	7.4%	2.5%	6.6%	2.5%	5.2%	2.5%
11	8.1%	2.5%	7.4%	2.5%	6.6%	2.5%	5.2%	2.5%
12	8.1%	2.5%	7.4%	2.5%	6.6%	2.5%	5.2%	2.5%

6.6.5.2 Trip Distribution

▲ <u>Three-dimensional balancing procedure</u>

As mentioned previously, the pattern of trip making is expected to change in future with certain traffic zones within the study area developing at a higher rate. This necessitated the development of "deterrence" matrices, which are used during a two-dimensional balancing procedure in EMME/2 to calculate future "balanced" O-D matrices by market segment and analysis period. These "deterrence" matrices were calculated with the aid of a three-dimensional balancing procedure in EMME/2, which entails the following:

- ⇨ The three-dimensional balancing procedure requires as input an input matrix (matrix to be balanced), an origin matrix (productions), a destination matrix (attractions), a third dimension (travel time index totals) and a third dimension matrix;
- ⇨ The third dimension was defined for each market segment and analysis period as the total number of trips occurring in each 5-min travel time interval. These totals were obtained by assigning the adjusted O-D matrices to the model network and calculating the trip length frequency diagram from the results (refer to Figure 6-13);
- ⇨ The third dimension matrix was obtained by converting the travel times (obtained from the above assignment) to travel time indices in the figure below;
- ⇨ When the input matrix equals one for all O-D pairs, the calculated third dimension balancing coefficients have the interpretation of the "deterrence" associated with a particular travel time index. These coefficients may be used to fit a deterrence function. These functions, when applied to the third dimension matrix (travel times), then serves as input into a two-dimensional trip distribution model as described in the modelling procedure.

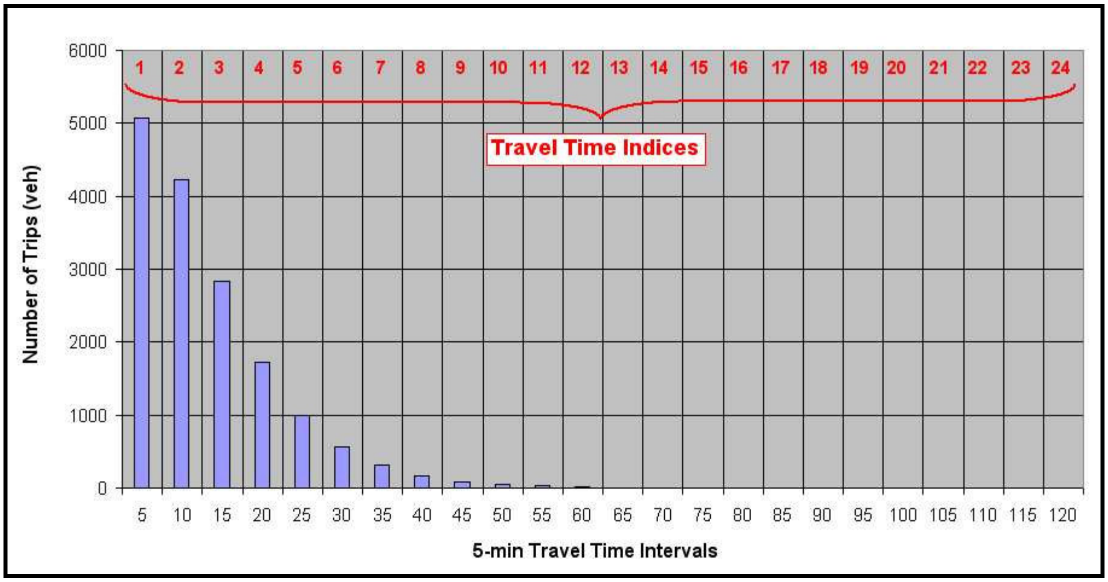


Figure 6-13: Trip Length Frequency vs. Travel Time Indices

▲ **Deterrence Functions**

A deterrence function represents the disincentive to travel as cost (travel time) increases. For the purpose of this study, it was decided to fit an exponential curve to the three-dimensional balancing coefficients with the following definition:

$$f(x) = \alpha.\exp(-\beta.x)$$

where:

α, β = constants

X = travel time index

The deterrence functions were calibrated by comparing the 2004 base year O-D matrices obtained from the two-dimensional balancing procedure with the adjusted O-D matrices (**Section 6.6.4**) and adjusting the constants α and β. Once calibrated, these deterrence functions were used to distribute trips between O-D pairs for each of the future year scenarios. A summary of the calibrated deterrence functions is given in Table 6-30 below (Figure 6-14 is an illustration of the deterrence functions by time of day):

Table 6-30: Calibrated Deterrence Functions

Analysis Period	α	β
Weekday AM	0.22	0.20
Weekday Off	0.28	0.25
Weekday PM	0.22	0.20
Weekday Night	0.35	0.30
Saturday AM	0.22	0.20
Saturday Off	0.28	0.25
Saturday PM	0.22	0.20
Saturday Night	0.35	0.30
Sunday AM	0.22	0.20
Sunday Off	0.28	0.25
Sunday PM	0.22	0.20
Sunday Night	0.35	0.30

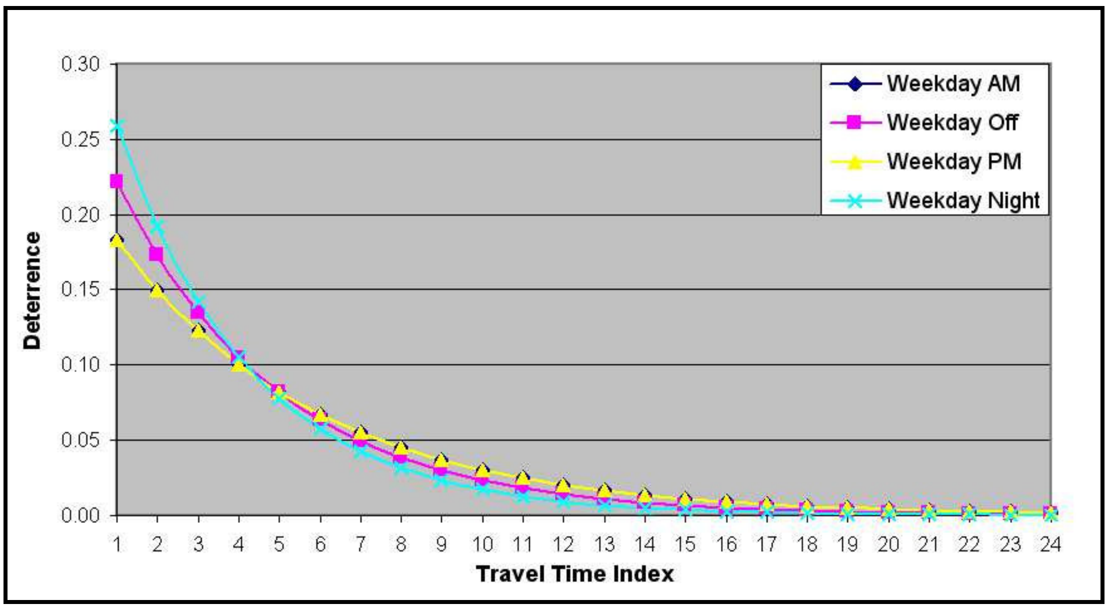


Figure 6-14: Calibrated Weekday Deterrence Functions

6.6.5.3 Trip Assignment

As described earlier, a multi-class equilibrium (capacity constrained) traffic assignment was performed during which each of the five balanced market segment matrices (private business, private commuter, private other, bus/taxi and heavy) was assigned simultaneously to the model network for each scenario. An example of the Weekday AM peak hour assignment results for 2007 is given by Figure 6-15. The following average **hours** were modelled:

- ⇨ Weekday: - AM peak, Off-peak, PM peak, Night
- ⇨ Saturday: - AM peak, Off-peak, PM peak, Night
- ⇨ Sunday: - AM peak, Off-peak, PM peak, Night

Hourly traffic volumes, obtained from the assignment results, in passenger car units (PCU's) were converted to vehicle volumes through application of the PCU factors described in Table 6-25. These volumes were then converted to average daily traffic (ADT) volumes through the application of the following equation:

$$ADT\,(veh/day) = \frac{\begin{array}{l} 5 * (WkAM * f_1 + WkOff * f_2 + WkPM * f_2 + WkNight * f_3) \\ + \quad SatAM * f_1 + SatOff * f_2 + SatPM * f_2 + SatNight * f_3 \\ + \quad SunAM * f_1 + SunOff * f_2 + SunPM * f_2 + SunNight * f_3 \end{array}}{7}$$

Where WkAM = Weekday AM peak hourly volume (veh/h)

f_1, f_2, f_3, f_4 = Conversion factors

Table 6-31: Peak Hour Conversion Factors

Period	f_1	f_2	f_3	f_4
Weekday	4	5	4	6
Saturday	4	5	4	6
Sunday	4	4	4	7

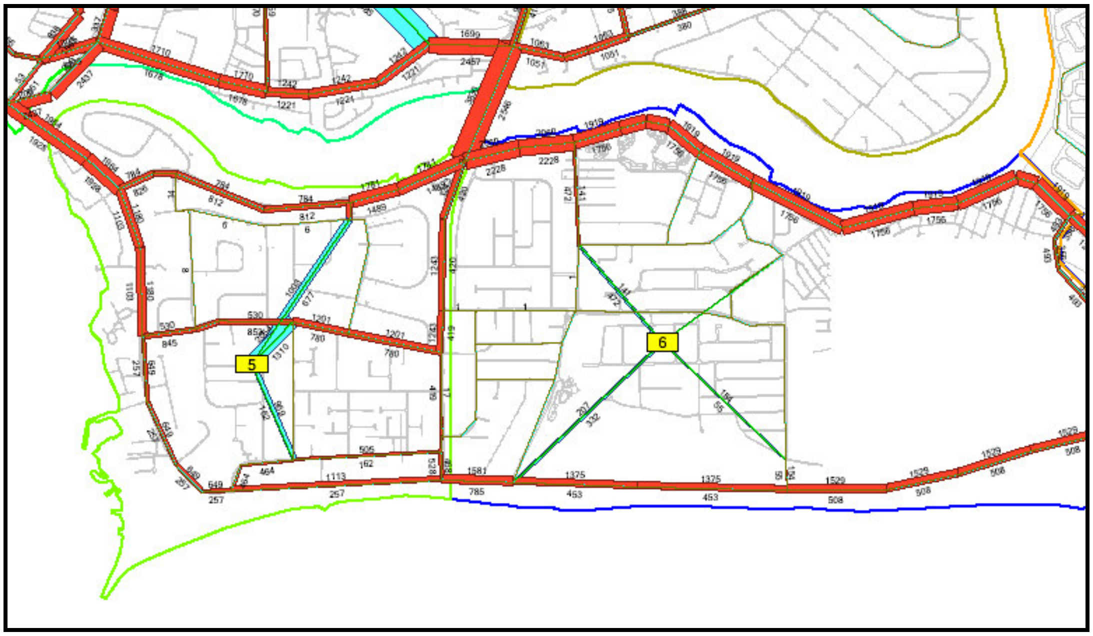


Figure 6-15: 2007 Weekday AM Peak Hour Assignment Results

6.7 MODELLED ROAD USER BENEFITS

The road user benefits were calculated directly from the assignment results in terms of average operating speed and average fuel consumption for each of the future analysis years for the following periods:

⇨ Weekday AM Peak Hour

⇨ Weekday Off-peak Hour

⇨ Daily Weighted Average

The calculated benefits are based on the average of the results obtained for selected links within the "Lekki Corridor". The assigned traffic volumes were used to weigh the results of each selected link. Several links were selected on the following road sections to ensure that the results reflect the expected benefits of the implementation of the proposed Epe Expressway and Coastal Toll Road project:

⇨ Ahmadu Bello Way: 4 sections;

⇨ Ozumba Mbadiwe Avenue: 1 section;

⇨ Maroko Road: 2 sections;

- ⇨ Akin Adesola Street: 3 sections;
- ⇨ New Epe Express Way: 11 sections;
- ⇨ Coastal Way (proposed): 14 sections;
- ⇨ Linkage roads: 9 sections.

Table 6-32 and Table 6-33 illustrate the modelled (expected) benefits of the projects in terms of increase in average speeds, decrease in travel time, and saving in fuel cost for the Lekki Corridor and the Lekki Corridor with the Southern Bypass respectively. These benefits increase for future periods with higher traffic demand.

Table 6-32: Modelled Expected Savings or Reductions in various MOE with the Lekki Corridor Project

BENEFITS APPLY TO PEAK DIRECTION				
Period		**Increase in Average Speed (km/h)**	**Decrease in Travel Time (min/km)**	**Saving in Fuel (l/km)**
2007	Weekday AM	17.9	0.39	0.023
	Weekday Off	7.9	0.13	0.003
	Weekday PM	17.4	0.38	0.018
	Weekday Night	0.1	0.00	0.000
	ADT	**7.4**	**0.13**	**0.007**
2012	Weekday AM	19.5	0.74	0.114
	Weekday Off	13.6	0.35	0.060
	Weekday PM	19.0	0.74	0.088
	Weekday Night	0.3	0.01	0.000
	ADT	**9.9**	**0.22**	**0.043**
2022	Weekday AM	37.5	4.06	2.069
	Weekday Off	21.1	0.98	1.629
	Weekday PM	36.1	4.05	1.681
	Weekday Night	0.9	0.01	0.000
	ADT	**21.3**	**0.69**	**0.926**
2037	Weekday AM	28.2	12.36	17.947
	Weekday Off	19.9	1.73	16.998
	Weekday PM	26.5	13.33	15.129
	Weekday Night	6.0	0.11	0.006
	ADT	**20.4**	**1.06**	**9.128**

Table 6-33: Modelled Expected Savings or Reductions in various MOE with the Lekki Corridor and Southern Bypass Project

BENEFITS APPLY TO PEAK DIRECTION					
Period		**Increase in Average Speed (km/h)**	**Decrease in Travel Time (min/km)**	**Saving in Fuel (l/km)**
2007	Weekday AM	15.0	0.35	0.020
	Weekday Off	3.1	0.05	-0.001
	Weekday PM	14.5	0.33	0.015
	Weekday Night	1.0	0.01	0.000
	ADT	**5.8**	**0.10**	**0.005**
2012	Weekday AM	21.5	0.78	0.113
	Weekday Off	12.5	0.33	0.058
	Weekday PM	22.8	0.83	0.091
	Weekday Night	0.8	0.01	0.000
	ADT	**10.3**	**0.22**	**0.042**
2022	Weekday AM	39.5	4.11	2.066
	Weekday Off	19.2	0.93	1.572
	Weekday PM	41.7	4.18	1.681
	Weekday Night	1.4	0.02	0.000
	ADT	**22.2**	**0.70**	**0.914**
2037	Weekday AM	29.3	12.42	17.746
	Weekday Off	18.8	1.68	16.827
	Weekday PM	30.4	13.56	14.957
	Weekday Night	4.4	0.08	0.004
	ADT	**21.1**	**1.08**	**9.041**

The figures below show that the average operating speeds in the Lekki Corridor for the scenario without the Coastal Freeway and without any tolls (daily weighted average results) are expected to decrease from 56.7 km/h in 2007 to a mere 25.2 km/h in 2037. The results are even more severe for the Weekday AM peak hour, with speeds decreasing from 49.0 km/h in 2007 to 11.9 km/h in 2037.

In contrast, with implementation of the Concession (Epe upgraded and the new Coastal Freeway both tolled) the daily weighted average speeds are expected to be 62.7 km/h in 2007 and 45.0 km/h in 2037. For the Weekday AM peak hour, speeds are expected to decrease from 61.7 km/h in 2007 to 34.6 km/h in 2037. Refer to Figure 6-16 and Figure 6-17.

Similar results are expected in terms of saving in fuel cost – refer to Figure 6-18 and Figure 6-19.

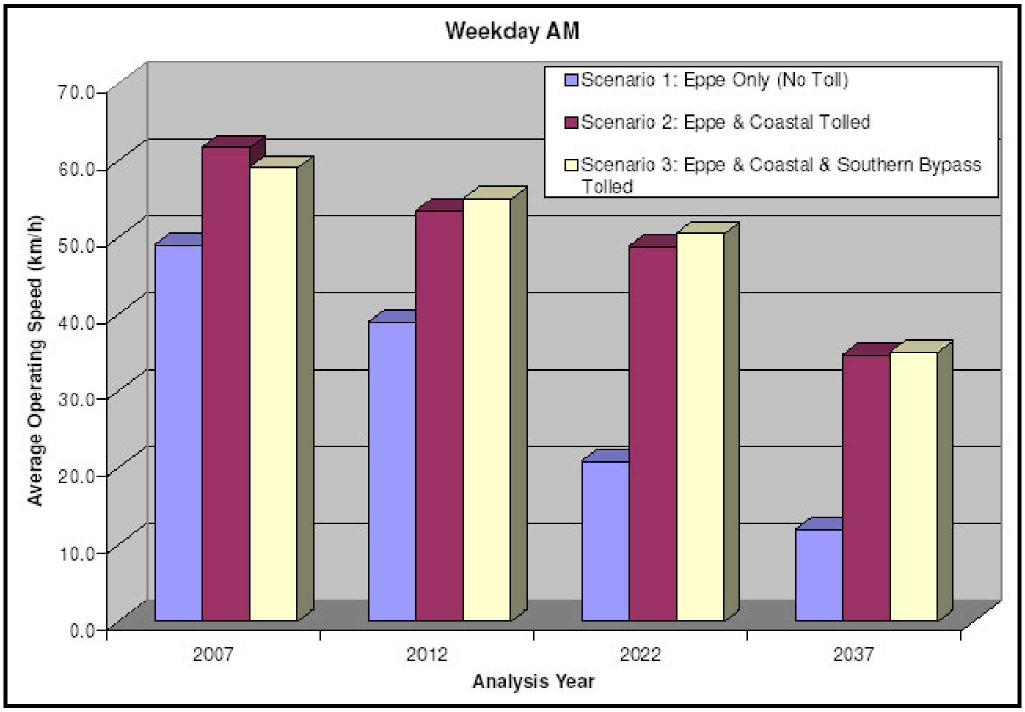


Figure 6-16: Weekday AM Peak Average Operating Speeds

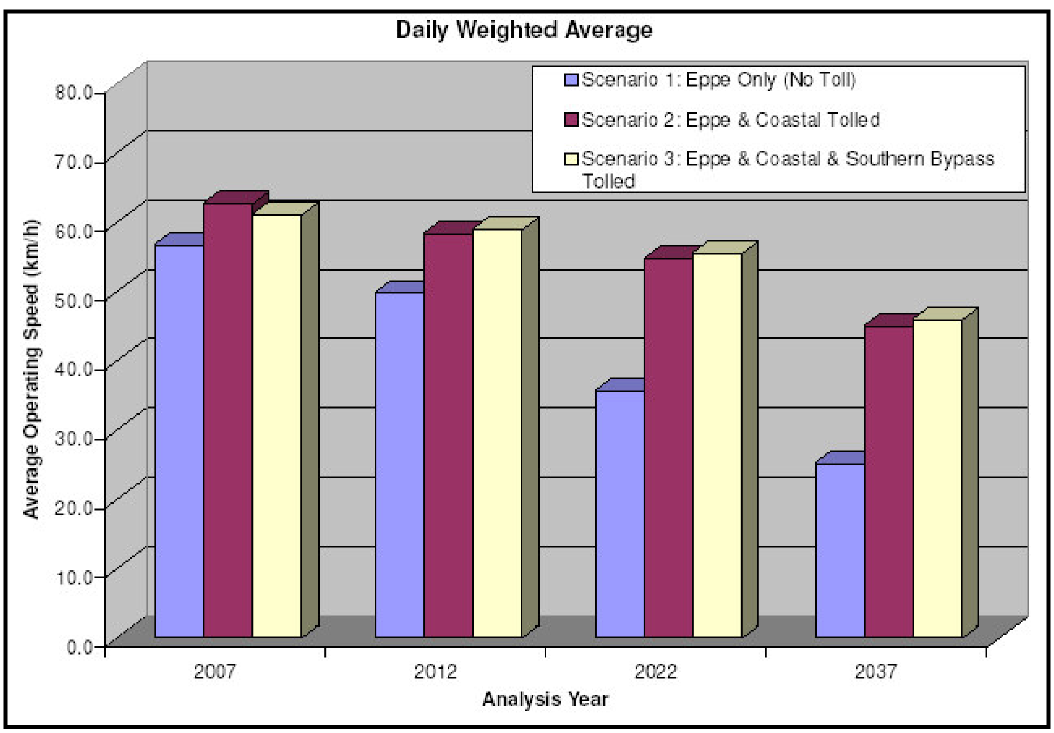


Figure 6-17: Daily Weighted Average Average Operating Speeds

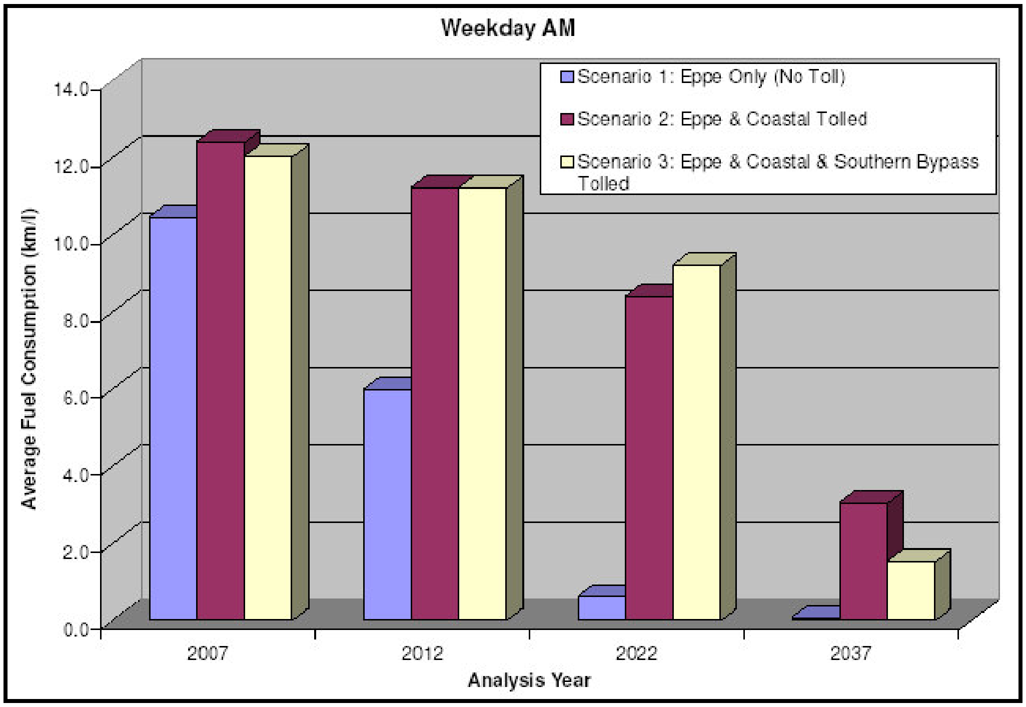


Figure 6-18: Weekday AM Peak Average Fuel Consumption

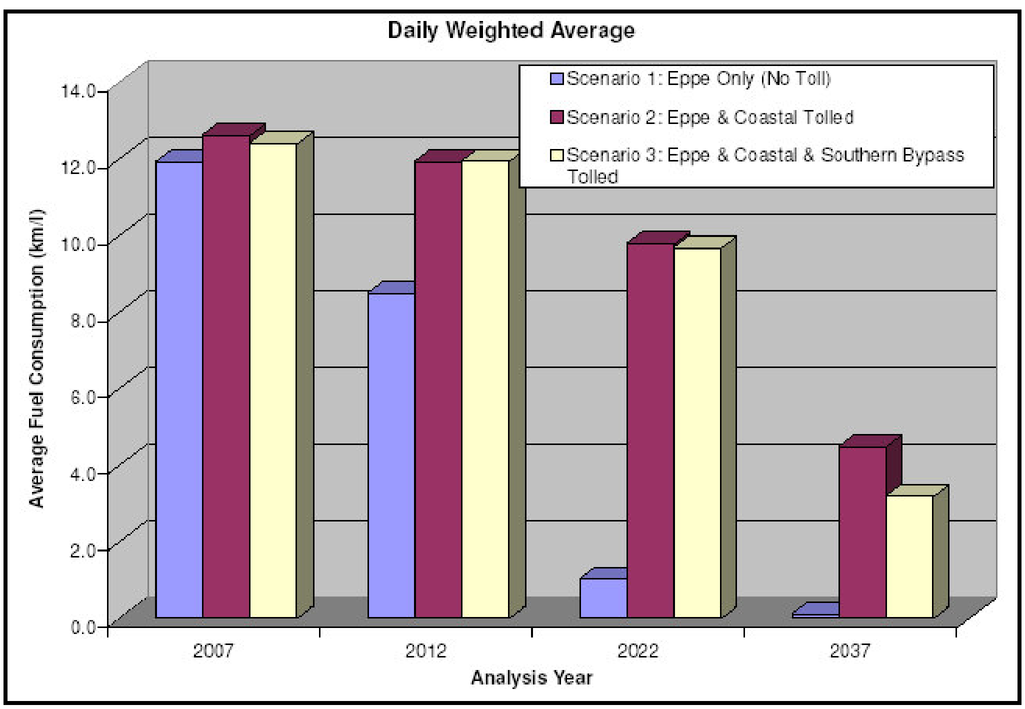


Figure 6-19: Daily Weighted Average Average Fuel Consumption

6.8 EXPECTED FUTURE TRAFFIC DEMAND

6.8.1 EXPECTED DEMAND WITHOUT TOLLS

It can be reasonably expected that the Coastal Freeway and the Southern Bypass would not be constructed without the BOT mechanism. Table 6-34 shows the expected traffic demand on Epe Expressway and Ahmadu Bello Way without any concessions, i.e. extension of existing situation. This demand is shown at the chosen three screen lines in the corridor (corresponds to the positions of the planned toll plazas for the other scenarios).

Table 6-34: Scenario without Concession, i.e. Only the Epe Expressway

Location	ADT (Vehicles)				Modal Split (%)		
	Private	Bus/taxi	Heavy	Total	Private	Bus/taxi	Heavy
2007							
Epe 1	35228	10272	2455	47955	73.5%	21.4%	5.1%
Epe 2	21651	8221	2047	31920	67.8%	25.8%	6.4%
Epe 3	10017	4209	1117	15343	65.3%	27.4%	7.3%
Ahmadu Bello 1	21506	2466	685	24658	87.2%	10.0%	2.8%
Ahmadu Bello 2	2484	677	140	3301	75.3%	20.5%	4.2%
2012							
Epe 1	56608	15080	3917	75605	74.9%	19.9%	5.2%
Epe 2	32408	12032	3252	47692	68.0%	25.2%	6.8%
Epe 3	13986	6049	1484	21518	65.0%	28.1%	6.9%
Ahmadu Bello 1	27317	4114	1001	32432	84.2%	12.7%	3.1%
Ahmadu Bello 2	6789	2082	423	9294	73.0%	22.4%	4.6%
2022							
Epe 1	101889	26267	7850	136006	74.9%	19.3%	5.8%
Epe 2	61931	22026	6362	90319	68.6%	24.4%	7.0%
Epe 3	27376	11157	2968	41501	66.0%	26.9%	7.2%
Ahmadu Bello 1	44755	8144	2188	55087	81.2%	14.8%	4.0%
Ahmadu Bello 2	16759	5112	1270	23141	72.4%	22.1%	5.5%
2037							
Epe 1	179336	46548	14204	240088	74.7%	19.4%	5.9%
Epe 2	108729	39151	11280	159160	68.3%	24.6%	7.1%
Epe 3	51205	20874	5614	77692	65.9%	26.9%	7.2%
Ahmadu Bello 1	113288	23893	5654	142835	79.3%	16.7%	4.0%
Ahmadu Bello 2	61173	17883	3780	82835	73.8%	21.6%	4.6%

6.8.2 EXPECTED DEMAND WITH TOLLS

6.8.2.1 Realistic Scenario

The expected traffic demand with tolls is shown in Table 6-35 for the Lekki Corridor and in Table 6-36 for the Lekki Corridor with the Southern Bypass in terms of vehicle classes, i.e. private, bus/taxi, and heavy vehicles.

Table 6-35: Lekki Corridor - Expected Traffic Demand With Tolls

LEKKI CORRIDOR							
Location	ADT (Vehicles)				Modal Split (%)		
	Private	Bus/taxi	Heavy	Total	Private	Bus/taxi	Heavy
2007							
Epe Toll 1	26245	9777	2124	38146	68.8%	25.6%	5.6%
Epe Toll 2	22578	8412	2219	33210	68.0%	25.3%	6.7%
Epe Toll 3	8941	3866	956	13763	65.0%	28.1%	6.9%
Coastal Toll 1	18419	1161	948	20527	89.7%	5.7%	4.6%
Coastal Toll 2							
Coastal Toll 3							
Ahmadu Bello 1	22989	3243	874	27106	84.8%	12.0%	3.2%
Ahmadu Bello 2	4154	1257	300	5711	72.7%	22.0%	5.3%
2012							
Epe Toll 1	31920	12926	2795	47641	67.0%	27.1%	5.9%
Epe Toll 2	31173	12054	3107	46334	67.3%	26.0%	6.7%
Epe Toll 3	13022	5738	1396	20157	64.6%	28.5%	6.9%
Coastal Toll 1	30192	2752	1696	34641	87.2%	7.9%	4.9%
Coastal Toll 2	411	35	22	468	87.7%	7.5%	4.8%
Coastal Toll 3							
Ahmadu Bello 1	27927	4736	1263	33925	82.3%	14.0%	3.7%
Ahmadu Bello 2	9387	2726	710	12823	73.2%	21.3%	5.5%
2022							
Epe Toll 1	41308	15332	3622	60262	68.5%	25.4%	6.0%
Epe Toll 2	41782	15305	4391	61479	68.0%	24.9%	7.1%
Epe Toll 3	13414	5704	1698	20816	64.4%	27.4%	8.2%
Coastal Toll 1	61733	10756	4036	76526	80.7%	14.1%	5.3%
Coastal Toll 2	15155	5599	1278	22032	68.8%	25.4%	5.8%
Coastal Toll 3	11094	4560	967	16621	66.7%	27.4%	5.8%
Ahmadu Bello 1	38990	10262	2309	51560	75.6%	19.9%	4.5%
Ahmadu Bello 2	17907	7517	1632	27055	66.2%	27.8%	6.0%
2037							
Epe Toll 1	60738	21334	5067	87140	69.7%	24.5%	5.8%
Epe Toll 2	59050	21834	6313	87197	67.7%	25.0%	7.2%

LEKKI CORRIDOR							
Location	ADT (Vehicles)				Modal Split (%)		
	Private	Bus/taxi	Heavy	Total	Private	Bus/taxi	Heavy
Epe Toll 3	19128	8532	2539	30199	63.3%	28.3%	8.4%
Coastal Toll 1	113921	23421	8294	145636	78.2%	16.1%	5.7%
Coastal Toll 2	40922	14558	3626	59107	69.2%	24.6%	6.1%
Coastal Toll 3	27418	10704	2492	40613	67.5%	26.4%	6.1%
Ahmadu Bello 1	108707	26608	5995	141310	76.9%	18.8%	4.2%
Ahmadu Bello 2	63300	21674	4318	89293	70.9%	24.3%	4.8%

Table 6-36: Lekki Corridor - Expected Traffic Demand With Tolls

LEKKI CORRIDOR WITH SOUTHERN BYPASS							
Location	ADT (Vehicles)				Modal Split (%)		
	Private	Bus/taxi	Heavy	Total	Private	Bus/taxi	Heavy
2007							
Epe Toll 1	29520	10688	2753	42961	68.7%	24.9%	6.4%
Epe Toll 2	22754	8670	2241	33665	67.6%	25.8%	6.7%
Epe Toll 3	8793	3809	930	13532	65.0%	28.1%	6.9%
Coastal Toll 1	17655	778	670	19104	92.4%	4.1%	3.5%
Coastal Toll 2							
Coastal Toll 3							
S Bypass Toll 1	24647	3654	360	28661	86.0%	12.7%	1.3%
S Bypass Toll 2	2587	15	0	2602	99.4%	0.6%	0.0%
S Bypass Toll 3	5805	0	0	5805	100.0%	0.0%	0.0%
Ahmadu Bello 1	8404	0	0	8404	100.0%	0.0%	0.0%
Ahmadu Bello 2	8404	0	0	8404	100.0%	0.0%	0.0%
2012							
Epe Toll 1	27003	14370	3588	44962	60.1%	32.0%	8.0%
Epe Toll 2	31253	11875	3088	46217	67.6%	25.7%	6.7%
Epe Toll 3	12683	5479	1334	19496	65.1%	28.1%	6.8%
Coastal Toll 1	36507	1168	1085	38760	94.2%	3.0%	2.8%
Coastal Toll 2	214	5	5	223	95.8%	2.1%	2.2%
Coastal Toll 3							
S Bypass Toll 1	34993	5686	916	41595	84.1%	13.7%	2.2%
S Bypass Toll 2	11777	53	6	11836	99.5%	0.4%	0.1%
S Bypass Toll 3	20438	17	0	20454	99.9%	0.1%	0.0%
Ahmadu Bello 1	32232	26	0	32258	99.9%	0.1%	0.0%
Ahmadu Bello 2	32242	26	0	32268	99.9%	0.1%	0.0%
2022							
Epe Toll 1	35082	16481	5325	56887	61.7%	29.0%	9.4%

LEKKI CORRIDOR WITH SOUTHERN BYPASS							
Location	ADT (Vehicles)				Modal Split (%)		
	Private	Bus/taxi	Heavy	Total	Private	Bus/taxi	Heavy
Epe Toll 2	39398	15746	4671	59816	65.9%	26.3%	7.8%
Epe Toll 3	13022	5782	1795	20599	63.2%	28.1%	8.7%
Coastal Toll 1	67268	9608	2167	79043	85.1%	12.2%	2.7%
Coastal Toll 2	17217	5229	933	23379	73.6%	22.4%	4.0%
Coastal Toll 3	11429	4474	863	16765	68.2%	26.7%	5.1%
S Bypass Toll 1	65701	9379	2419	77499	84.8%	12.1%	3.1%
S Bypass Toll 2	36115	713	10	36838	98.0%	1.9%	0.0%
S Bypass Toll 3	40024	7361	11	47396	84.4%	15.5%	0.0%
Ahmadu Bello 1	65839	12109	19	77966	84.4%	15.5%	0.0%
Ahmadu Bello 2	65933	12126	19	78077	84.4%	15.5%	0.0%
2037							
Epe Toll 1	58785	23653	6873	89311	65.8%	26.5%	7.7%
Epe Toll 2	55289	23571	6999	85860	64.4%	27.5%	8.2%
Epe Toll 3	18073	8929	2801	29803	60.6%	30.0%	9.4%
Coastal Toll 1	116487	21392	6546	144425	80.7%	14.8%	4.5%
Coastal Toll 2	44519	13065	3005	60590	73.5%	21.6%	5.0%
Coastal Toll 3	28899	10499	2326	41724	69.3%	25.2%	5.6%
S Bypass Toll 1	119692	24173	5434	149299	80.2%	16.2%	3.6%
S Bypass Toll 2	74833	8627	992	84452	88.6%	10.2%	1.2%
S Bypass Toll 3	75910	17483	2118	95511	79.5%	18.3%	2.2%
Ahmadu Bello 1	109281	25168	3050	137499	79.5%	18.3%	2.2%
Ahmadu Bello 2	114192	26299	3187	143677	79.5%	18.3%	2.2%

6.8.2.2 Results Sensitivity Analyses

Sensitivity analyses on the traffic forecasting were done by assuming different traffic growth rates for the future, i.e. a pessimistic scenario with a 1.0% lower growth rate and an optimistic scenario with a 1.0% higher growth rate was assumed for comparison with the expected (realistic scenario). The weighted average growth rates during the concession period were therefore as follows:

- ⇨ Realistic scenario 4.9% pa
- ⇨ Pessimistic scenario 4.0% pa
- ⇨ Optimistic scenario 5.9% pa

The forecasted traffic demand with tolls for the Lekki Corridor and the Lekki Corridor with the Southern Bypass is shown in Table 6-37 and Table 6-38, respectively.

Table 6-37: Sensitivity Analyses - Expected Demand for Lekki Corridor

LOCA-TION	TOLL CLASS	REALISTIC SCENARIO				PESSIMISTIC SCENARIO				OPTIMISTIC SCENARIO			
		2007	2012	2022	2037	2007	2012	2022	2037	2007	2012	2022	2037
Epe 1	Class 1	35676	44390	56100	81320	35676	42306	48467	60647	35676	46555	64844	108729
	Class 2	1593	2098	2668	3730	1593	2001	2306	2782	1593	2199	3082	4986
	Class 3	823	1083	1403	1964	823	1033	1213	1465	823	1135	1621	2624
	Class 4	53	70	91	127	53	67	78	95	53	73	105	170
Coastal 1	Class 1	19538	32848	72116	136535	19538	31394	62812	102925	19538	34355	82695	180643
	Class 2	598	1093	2745	5684	598	1045	2396	4297	598	1142	3142	7499
	Class 3	368	657	1563	3209	368	629	1363	2424	368	687	1790	4238
	Class 4	24	43	101	208	24	41	88	157	24	44	116	274
Epe 2	Class 1	30693	42800	56549	80116	30693	40835	48929	59827	30693	44841	65265	106983
	Class 2	1601	2251	3119	4477	1601	2148	2700	3346	1601	2358	3598	5975
	Class 3	860	1205	1701	2446	860	1149	1473	1828	860	1262	1962	3263
	Class 4	56	78	110	158	56	74	95	118	56	82	127	211
Coastal 2	Class 1	1	444	20536	54912	1	438	18897	43878	1	451	22306	68596
	Class 2	1	15	960	2673	1	14	872	2111	1	15	1055	3379
	Class 3	1	9	503	1427	1	9	456	1122	1	9	555	1810
	Class 4	1	1	33	95	1	1	29	73	1	1	38	123
Epe 3	Class 1	12670	18557	18919	27363	12670	17713	16335	20394	12670	19433	21880	36608
	Class 2	698	1023	1198	1790	698	977	1036	1336	698	1071	1383	2391
	Class 3	371	541	657	982	371	517	569	734	371	567	759	1312
	Class 4	24	35	43	64	24	33	37	47	24	37	49	85
Coastal 3	Class 1	1	1	15476	37702	1	1	14171	29951	1	1	16891	47366

LOCA-TION	TOLL CLASS	REALISTIC SCENARIO				PESSIMISTIC SCENARIO				OPTIMISTIC SCENARIO			
		2007	2012	2022	2037	2007	2012	2022	2037	2007	2012	2022	2037
	Class 2	1	1	738	1865	1	1	667	1462	1	1	817	2374
	Class 3	1	1	381	981	1	1	343	767	1	1	423	1253
	Class 4	1	1	25	65	1	1	22	50	1	1	28	84

Table 6-38: Sensitivity Analyses - Expected Demand for Lekki Corridor with Southern Bypass

LOCA-TION	TOLL CLASS	REALISTIC SCENARIO				PESSIMISTIC SCENARIO				OPTIMISTIC SCENARIO			
		2007	2012	2022	2037	2007	2012	2022	2037	2007	2012	2022	2037
Epe 1	Class 1	39830	40874	50999	81614	39830	38881	43971	60803	39830	42948	59065	109235
	Class 2	1995	2610	3698	4865	1995	2489	3200	3631	1995	2736	4268	6501
	Class 3	1067	1388	2057	2660	1067	1324	1781	1985	1067	1455	2373	3553
	Class 4	69	90	133	172	69	86	115	128	69	94	154	230
Coastal 1	Class 1	18406	37632	76533	137145	18406	36029	66727	103436	18406	39291	87671	181362
	Class 2	421	680	1614	4584	421	649	1406	3471	421	711	1850	6040
	Class 3	260	421	842	2531	260	403	733	1914	260	441	967	3338
	Class 4	17	27	54	164	17	26	47	124	17	29	63	216
Epe 2	Class 1	31117	42708	54595	78041	31117	40741	47216	58255	31117	44750	63039	104251
	Class 2	1623	2234	3296	4936	1623	2131	2855	3691	1623	2341	3801	6581
	Class 3	869	1197	1808	2708	869	1142	1566	2026	869	1254	2084	3610
	Class 4	56	77	117	175	56	74	101	131	56	81	135	234
Coastal 2	Class 1	1	218	22239	57061	1	215	20525	45711	1	222	24086	71101
	Class 2	1	3	745	2261	1	3	676	1782	1	3	821	2863

LOCA-TION	TOLL CLASS	REALISTIC SCENARIO				PESSIMISTIC SCENARIO				OPTIMISTIC SCENARIO			
		2007	2012	2022	2037	2007	2012	2022	2037	2007	2012	2022	2037
	Class 3	1	2	370	1189	1	2	333	932	1	2	410	1512
	Class 4	1	0	25	79	1	0	22	60	1	0	28	104
Epe 3	Class 1	12467	17968	18603	26694	12467	17148	16063	19895	12467	18819	21515	35716
	Class 2	681	977	1256	1956	681	933	1087	1462	681	1023	1450	2609
	Class 3	361	517	694	1083	361	494	601	810	361	542	801	1444
	Class 4	23	33	45	70	23	32	39	52	23	35	52	93
Coastal 3	Class 1	1	1	15729	38988	1	1	14403	30979	1	1	17166	48970
	Class 2	1	1	674	1760	1	1	608	1379	1	1	746	2241
	Class 3	1	1	340	917	1	1	306	716	1	1	378	1171
	Class 4	1	1	22	60	1	1	20	46	1	1	25	78
Southern Bypass 1	Class 1	28172	40482	74767	143061	28172	38634	64920	107524	28172	42400	85993	189831
	Class 2	341	736	1742	4016	341	705	1522	3042	341	769	1992	5289
	Class 3	139	353	930	2087	139	339	814	1584	139	368	1061	2742
	Class 4	9	23	60	135	9	22	53	102	9	24	69	177
Southern Bypass 2	Class 1	2599	11828	36803	83190	2599	11398	32422	63539	2599	12271	41731	108656
	Class 2	1	5	31	860	1	5	27	679	1	6	35	1087
	Class 3	1	2	4	377	1	2	3	294	1	2	5	482
	Class 4	1	0	0	25	1	0	0	19	1	0	0	33
Southern Bypass 3	Class 1	5802	20452	47130	92858	5802	19669	41326	70498	5802	21259	53688	122002
	Class 2	1	1	262	1804	1	1	234	1415	1	1	292	2295
	Class 3	1	1	4	796	1	1	4	624	1	1	5	1013
	Class 4	1	1	0	53	1	1	0	40	1	1	0	69

6.8.3 UTILIZATION OF TOLL PLAZAS

It is recommended that the same toll tariff be levied at Toll Plazas 1, 2, and 3 on both the Epe Expressway and the Coastal Freeway. The various toll rates will therefore add up depending on the number of plazas that is utilized by the users. The weighted average numbers of toll plazas that will be used by users of Toll Plazas 1, 2, and 3 respectively are shown in Table 6-39. Inspection of Table 6-39 shows:

- ⇨ The number of toll plazas that will be used by motorists (at the same location) increases over times as development moves in an eastern direction over time;
- ⇨ Motorists at Toll Plaza 2 use more plazas as motorists at Toll Plaza 1, and similarly for Toll Plaza 3 versus Toll Plaza 2;
- ⇨ The weighted average number of toll plazas that will be used by users of Toll Plaza 1 is 1.67, compared to 2.20 for users of Toll Plaza 2, compared to 2.57 for users of Toll Plaza 3 in 2012.
- ⇨ The overall weighted average number of toll plazas that will be used by users is approximately 2.0.

Table 6-39: Utilization of Toll Plazas

Going Through # Screen Lines			2007	2012	2022	2037
At screen line	1	1	54%	52%	46%	42%
		2	30%	30%	32%	31%
		3	16%	19%	22%	27%
	Weighted Average		**1.63**	**1.67**	**1.76**	**1.85**
	2	1	15%	13%	11%	8%
		2	56%	55%	53%	50%
		3	29%	33%	36%	42%
	Weighted Average		**2.14**	**2.20**	**2.25**	**2.34**
	3	1	23%	19%	16%	10%
		2	7%	6%	4%	3%
		3	70%	76%	80%	86%
	Weighted Average		**2.47**	**2.57**	**2.64**	**2.76**
Weighted Average for Corridor			**1.90**	**1.96**	**2.05**	**2.16**

6.9 CAPACITY AND OPERATIONAL ANALYSES

The number of lanes required in the Lekki Corridor, and the resulting capacity, was calculated by means of the procedure prescribed in the Highway Capacity Manual (HCM2000). The following parameters were accepted for this calculation:

- ⇨ Intersection density of 1km for non-freeways and interchange density of 2.5km for freeways;
- ⇨ Lane width of 3.6 meters;
- ⇨ Terrain level;
- ⇨ % Trucks of 7%;
- ⇨ Free flow speed of 80 km/h for the two-lane and multi-lane roads and 100 km/h for the freeways;
- ⇨ Peak hour factor of 0.95;
- ⇨ Peak hour coefficient of 10%; and
- ⇨ Directional split of 60%.

The maximum AADT levels for the various Levels of Service (LOS) for a 2-lane Rural Road, 4- and 6-lane Multi lane Road, and 4- and 6-lane Freeway are shown in Table 5-26.

Table 6-40: Level of Service Definition based on AADT

LOS	Rural Road	Multi Lane Urban Road		Freeways	
	2-Lanes	4-Lanes	6-Lanes	4-Lanes	6-Lanes
LOS A	< 2,500	< 15,800	< 24,200	< 19,200	< 29,200
LOS B	< 2,500	< 25,800	< 38,300	< 30,000	< 46,700
LOS C	< 2,500	< 37,500	< 56,700	< 44,200	< 68,300
LOS D	**< 11,700**	**< 50,800**	**< 76,700**	**< 60,000**	**< 91,700**
LOS E	< 26,700	< 61,700	< 92,500	< 68,300	< 103,300
LOS F	> 26,700	> 61,700	> 92,500	> 68,300	> 103,300

The required number of lanes to maintain a minimum LOS D was subsequently calculated for every future year and all three scenarios, i.e. realistic, pessimistic, and optimistic. The capacity required, and the time of upgrading to maintain LOS D, was surprisingly very similar (only some improvements have moved up or down one or two years).

Improvements required during the last 5-years of the concession, especially upgrading to 8-lanes on the western sections of the Epe Expressway and/or the Coastal Freeway was furthermore not implemented given that it is very far into the future and close to the end of the concession.

Two options were furthermore investigated, namely a low and a high capex scenario. The high capex scenario included the upgrading of the Coastal Freeway to a 4-lane freeway from the 4th Mainland Bridge Link to Eleko Beach at year 20 of the concession. Linked to this improvement is the upgrading of the last five linkages between Epe Expressway and the Coastal Freeway from 2-lane to 4-lane urban arterials. With the low capex scenario this section remains a 2-lane rural highway throughout the concession period and the linkages also remains 2-lane urban arterials. The cost of these improvements amounts to USD 70.0 million in year 20 (2026) of the concession.

The recommended improvements for the two options are shown in Table 6-41 and Table 6-42 respectively for the low capex and the high capex scenarios.

Table 6-41: Recommended Improvement during Concession Period - Low Capex Scenario

Period from start of concession			10 Years	15 Years	20 Years	30 Years
Year end			2016	2021	2026	2036
Epe Express-way	Falomo to Lekki	1	6-lane Urban Arterial			
	Lekki to 4th Mainland	2	6-lane Urban Arterial			
	4th Mainland to Eleko Beach	3	4-lane Rural Arterial	4 Rural Arterial (Upgrade)		
Coastal Freeway	Akin Adesola to Lekki	1	4-lane Freeway		6-lane Freeway	
	Lekki to 4th Mainland	2	2-lane Rural Highway	4-lane Freeway		
	4th Mainland to Eleko Beach	3	None	2-lane Rural Highway		
Links	Admiralty + Lekki	1	4-lane Urban Arterial			
	Gbari + Chevron + 4th Mainland	2	2-lane Urban Arterial	4-lane Urban Arterial		
	Sangotedo + 3x New Town + Eleko Beach	3	None	2-lane Urban Arterial		

Period from start of concession			10 Years	15 Years	20 Years	30 Years
Year end			2016	2021	2026	2036
Southern Bypass	Ring Road to Akin Adesola	1	4-lane Freeway	6-lane Freeway		

Table 6-42: Recommended Improvement during Concession Period – High Capex Scenario

Period from start of concession			10 Years	15 Years	20 Years	30 Years
Year end			2016	2021	2026	2036
Epe Express-way	Falomo to Lekki	1	6-lane Urban Arterial			
	Lekki to 4th Mainland	2	6-lane Urban Arterial			
	4th Mainland to Eleko Beach	3	4-lane Rural Arterial	4 Rural Arterial (Upgrade)		
Coastal Freeway	Akin Adesola to Lekki	1	4-lane Freeway		6-lane Freeway	
	Lekki to 4th Mainland	2	2-lane Rural Highway	4-lane Freeway		
	4th Mainland to Eleko Beach	3	None	2-lane Rural Highway		4-lane Freeway
Links	Admiralty + Lekki	1	4-lane Urban Arterial			
	Gbari + Chevron + 4th Mainland	2	2-lane Urban Arterial	4-lane Urban Arterial		
	Sangotedo + 3x New Town + Eleko Beach	3	None	2-lane Urban Arterial		4-lane Urban Arterial
Southern Bypass	Ring Road to Akin Adesola	1	4-lane Freeway	6-lane Freeway		

6.10 RECOMMENDATIONS

A uniform upgrading program was identified for all three scenarios, i.e. realistic, pessimistic, and optimistic, for the Lekki Corridor and the Lekki Corridor with the Southern Bypass. Two different options exist, however: namely a low capex and a high capex option.

The high capex option is recommended and consists of the upgrading of the eastern section of the Coastal Road to a four-lane freeway at year 20 of the concession (it also includes the upgrading of the five most eastern link roads to four-lane urban arterials).

6.11 REFERENCES

1 Spiess, H. A Gradient Approach for the O-D Matrix Adjustment Problem, EMME/2 Support Center, Haldenstrasse 16, CH-2558 Aegerten, Switzerland, May 1990.

2 Papacostas, C.S. and Prevedouros, P.D. Transportation Engineering and Planning, 1997, USA.

3 Les Conseillers INRO Consultants Inc. EMME/2 User's Manual – Software Release 9, August 1998.

7 ESTIMATED CONSTRUCTION AND MAINTENANCE COST

7.1 COST INVESTIGATION

A comprehensive costing investigation was done during the Pre-feasibility Stage of the study. The results of this investigation are discussed in the following section.

7.1.1 ROADS

The following references were independently used in the conceptual design of the road pavement layers:

- ⇨ Roadnote 31 (1993) A guide to the structural design of bitumen-surfaced roads in tropical and sub-tropical countries, Transport Research Laboratory, Crowthorne, Berkshire, United Kingdom.
- ⇨ TRH4 (1996) Structural design of flexible pavements for interurban and rural roads. Department of Transport, Pretoria, South Africa.

The pavement design is based on a 20-year design life. Full flow traffic conditions are assumed with a 3.5 E80 (Equivalent 80kN axle) load factor and a 6 % growth rate. This resulted in an ES10 (TRH4, 1996) or T5 (Roadnote 31, 1993) design traffic load. Based on an analysis using available rates and the proposed catalogue pavement structures, a crushed stone granular base pavement was found to be the most economical base material. Accordingly, the following pavement structure is proposed:

- ⇨ 50mm asphalt surfacing,
- ⇨ 150mm dense unweathered crushed stone base,
- ⇨ 300mm cement stabilized subbase (UCS > 1500 kPa; ITS > 250 kPa),
- ⇨ 150mm natural gravel upper selected (CBR > 15% @ 93% Mod. AASHTO),
- ⇨ 150mm natural gravel lower selected (CBR > 7% @ 93% Mod. AASHTO).

7.1.1.1 Initial construction cost

Rates were obtained from a Nigerian Contractor (Marlum Nigeria) and consulting engineers (Ove Arup) currently involved in road construction in Nigeria. The items with corresponding rates that were used to estimate the construction cost of the roads for the different projects are tabled overleaf:

Table 7-1: Road Construction Rates

ITEM NO	DESCRIPTION	UNIT	RATE (DOLLAR)
17.01	Clearing and grubbing	ha	1429.00
33.09	Material bladed to windrow	m^3	32.00
33.10	Roadbed preparation		
(b)	150mm to 93% mod AASHTO	m^3	32.00
B34.01	Gravel Pavement layers from cut or borrow incl Haul		
(a)(i)	Gravel selected, 93% mod AASHTO	m^3	36.00
(c)(i)	Subbase, 95% mod AASHTO	m^4	50.00
(e)(i)	Base, 150mm, 98% mod AASHTO	m^3	104.00
35.01	Chemical stabilization	m^3	9.00
35.02	Stabilizing agent	t	143.00
41.01	Prime Coat		
(b)	MC-30	Litre	1.00
42.02	Asphalt surfacing		
(a)	Continuously graded	t	221.00
42.04	Tack coat of 30% stable grade emulsion sprayed at 0.6 l/m^2	Litre	1.00
59.01	Finishing the road and road reserve:		
(b)	Single-carriageway road	km	1714.00

Preliminary quantities were calculated for various proposed cross-sections. Table 7-2 below indicates the summarized cost per typical cross-section.

Table 7-2: Summarized Road Construction Cost Estimate

SECTION	COST (USD/KM)	COST ($\$/M^2$)
Section A – 2 lane ramp	1,028,404.59	93.49
Section B – 1 lane ramp	773,956.44	96.74
Section C – 4 lane	1,985,396.95	98.28
Section D – 4 lane with aux lanes	2,579,109.30	94.82
Section E – 6 lane	2,690,799.17	87.93
Section F – 4 lane	2,097,086.82	88.86
Coastal road section A - 6 lane	2,773,249.73	94.33
Coastal road section B - 4 lane + 2 lane frontage	5,333,942.75	91.65

It is evident that the estimated road unit cost is fairly similar for the different road cross-sections. For simplicity of costing calculations, the unit rate of USD 91.65 / m^2 for the four-lane Coastal Road will be used to estimate the construction cost of all roads on the project. Adding an estimated 15% for contractor's preliminary and general items, the assumed road construction rate is **USD 105 / m^2**.

7.1.1.2 Periodic and routine maintenance

Other pavement-related project capital cost entails routine maintenance and periodic maintenance. The following rates are assumed:

- ⇨ Annual routine maintenance: USD 0.45 / m^2
  - ♦ (crack seal, pothole repair, painting)
- ⇨ 10 Year periodic maintenance: USD 25 / m^2
  - ♦ (asphalt overlay)
- ⇨ 20 Year periodic maintenance: USD 48 / m^2
  - ♦ (new emulsion treated base and asphalt overlay)

7.1.2 BRIDGES

Bridge construction activity has been fairly limited in Lagos State in recent years. The last of the major bridges, 3rd Mainland Bridge was completed more than fifteen years ago. The absence of recent major bridge construction project makes accurate cost estimating a very risky exercise.

Accurate construction quantities are generally not calculated during pre-feasibility or feasibility project stages. It is customary to estimate costs related to bridge construction by considering overall unit rates, i.e. cost per square metre of deck area. Given the significant contribution of the bridge construction cost to the total project cost, combined with the uncertainties with respect to construction rates in Nigeria, the following multi-level approach will be followed:

- ⇨ A literature search to establish recent rate estimates published by developers in Nigeria.
- ⇨ A project database search to review actual costs of recently constructed bridges worldwide, of a similar type and configuration as the proposed bridge configurations.

- ⇨ The computation of bridge unit rate cost by multiplication of calculated main component quantities with current rates obtained from Nigerian contractors and consultants.

- ⇨ The computation of bridge unit rate cost from a continental perspective, calibrated for local conditions by using regional material and labour rates.

Since the proposed viaduct bridges in the lagoon have a significant impact on the total capital project cost, this study will concentrate on this bridge configuration. Unit rates for other configurations of bridges on the project will be derived from the calculated unit rates for the lagoon viaducts.

7.1.2.1 Bridge configuration

The following conceptual bridge configurations are foreseen for the different projects:

▲ **Viaduct**

Long-span bridges are required wherever a lagoon or marshland is crossed. Figure 10.1 shows a proposed viaduct that can be constructed with the balanced cantilever method. Support positions are limited by using long deck spans in the order of 100m. Foundations are on large diameter in-situ cast reinforced concrete piles that are driven approximately 35m into the sand bed. The substructure and superstructure of this bridge configuration are constructed monolithic. The prestressed concrete deck can be constructed in situ, or with the use of prefabricated segmental construction.

▲ **Elevated Expressway**

Figure 10.2 displays a proposed bridge configuration that can be used where an expressway is required on top of an existing urban road. Foundations consist of small to medium size in situ driven reinforced concrete piles. The substructure consists of reinforced concrete portals, which can partially be constructed using prefabricated construction. The superstructure consists of medium-span prestressed concrete beams with an in-situ cast reinforced concrete deck slab.

▲ **Interchange and Ramp Bridges**

The bridges forming part of interchanges on all projects will be constructed by using conventional bridge configurations. Figure 10.3 shows the various deck types for different bridge lengths and widths.

Founding will be on small to medium diameter in situ driven reinforced concrete piles. The substructure will consist of reinforced concrete closed wall abutments and multi-column piers. The superstructure will be reinforced concrete voided slab decks for span lengths up to 25 m and prestressed concrete box girders for longer spans.

7.1.2.2 Literature search

This section summarizes the findings of a literature search, during which recent proposal documents from project developers were scrutinized with the purpose to obtain estimated rates for bridge construction.

▲ **Outline of Alternatives Report – Third Link Road for Lagos Island / Ikoyi to Victoria Island / Lekki Peninsula (June 2002) [Encon International]**

The report included a cost estimate for two-lane dual carriage bridges. The total deck width of these bridges is 23m (combined carriageways)

The unit cost estimates in the report are as follows:

- ⇨ 1 km long bridge: USD 1000/m^2 [USD 1060 / m^2]
- ⇨ 4 km long bridge: USD 957 / m^2 [USD 1015 / m^2]
- ⇨ 7 km long bridge USD 870 / m^2 [USD 920 / m^2]

The rates in square brackets were obtained by inflating the actual rates by 3% over two years. The average inflated rate for the three lengths of bridges is USD 1000 / m2 (rate per square metre of plan deck area).

▲ **Report on a proposed development of Lekki Peninsula Coastal Road (November 2000) [Encon International]**

The following unit rate was extracted from a bill of quantities in the report:

- ⇨ Construction of short bridges: N 100 000 / m^2
(USD 714) [**USD 1 085**]

The assumed exchange rate for the conversion to US dollar is 1 US Dollar to 140 Nigerian Niarra. The figure in square brackets depict the present day rates in US Dollars assuming that the Nigerian currency has depreciated by 15% per annum, in line with average annual inflation gap between the two currencies.

▲ **Data collection and diagnostic report – Mass Transit and Transport Systems Management Programme for Lagos Metropolitan Area (1992) [Dar Al-Handash]**

The following bridge construction unit rates were extracted from the report:

- ⇨ Interchange bridges USD 1 400 / m^2 [USD 2000 / m^2]
- ⇨ Lagoon viaduct: USD 2 500 / m^2 [USD 3560 / m^2]
- ⇨ Overland viaduct: USD 1 940 / m^2 [USD 2760 / m^2]

The rates in square brackets were obtained by inflating the actual rates by 3% over twelve years. The average inflated rate for the three lengths of bridges is **USD 2770/m^2**. However, the assumed total inflation of 42% over 12 years is probably on the conservative side.

▲ **Literature Search Summary**

Table 7-3: Literature Search Summary	
Lowest recorded unit rate	USD 920 / m^2
Average recorded unit rate	USD 1618 / m^2
Highest recorded unit rate	USD 3560 / m^2

7.1.2.3 Project database search

Table 7-4 displays the results of a search conducted to evaluate the construction cost of recently constructed bridges. Only bridges constructed with methods similar to the proposed lagoon viaduct bridges were considered.

Table 7-4: Project Database Search

COUNTRY	BRIDGE NAME	BRIDGE LENGTH	DECK WIDTH	YEAR COMPLE-TED	CONSTRUC-TION COST	ESCALATED CONVERTED UNIT RATE
Germany	Besseringen Bridge	222m 98,1m longest span	11,5m	1999	DM 8,35 million	USD 2370/m^2
France	La Barricade Viaduct	420m 150m longest span (60m highest pier)	19m	1997	FF 105 million	USD 3021/m^2
Europe	Mainbruche Bettingen	310m 140m longest span	36,5m	2001	E 22,6 million	USD 2978/m^2
Zambia	Chirundu Bridge	400m 100m longest span	10m	2001	USD 14 million	USD 3398/m^2

Table 7-5: Project Database Summary

Lowest recorded unit rate	USD 2370 / m^2
Average recorded unit rate	USD 2941 / m^2
Highest recorded unit rate	USD 3398 / m^2

7.1.2.4 Detailed cost estimate

A wide range of unit rates was encountered during the preceding literature survey and project database search. In order to narrow the range of estimated bridge construction cost, preliminary main component quantities were computed for the proposed lagoon bridges. The magnitudes of these quantities were verified with technical information obtained during the database search for construction costs.

A hypothetical six-lane bridge, with piled supports at 100m centres, was considered during the costing exercise. The calculated preliminary construction quantities are as follows:

- ⇨ Deck concrete 30 m^3 / m deck [1 m^3 / m^2]
- ⇨ Formwork 75 m^2 / m deck [horizontal and vertical]
- ⇨ Reinforcement 4,5 t / m deck [150 kg / m^3]
- ⇨ Prestressing 310 MN.m / m deck [50 kg / m^3]
- ⇨ Driven piles 4,2 m / m deck [12 x 1,5 dia x 35m piles per
- ⇨ Support
  - ♦ Pier concrete 6,8 m^3 / m deck
  - ♦ Pier formwork 10,7 m^2 / m deck
  - ♦ Pier reinforcement 1,0 t / m deck [150 kg / m^3]

Current rates for these construction quantities were obtained from commercial contractors in Lagos. A priced schedule of quantities is played below:

Table 7-6: Bridge Construction Unit Cost (Nigerian Contractor Rates)

DESCRIPTION	UNIT	QUANTITY	RATE (USD)	TOTAL (USD)
30 MPa concrete	m^3	36.8	185-71	6 843-13
High tensile reinforcement	t	5.5	1 360-00	7 480-00
Prestressing	MN.m	310	35-00	10 850-00
Formwork	m^2	85.7	53-57	4 590-95
Driven Piles	m	4.2	2 650-00	11 130-00
			SUBTOTAL / m	40 885-08
Access and drainage			15%	6 132-76
Miscellaneous other items			10%	4 088-51
			SUBTOTAL	51 108-35
Contractor's preliminary and general			15%	7 666-25
			TOTAL / m	58 774-00
			TOTAL / m^2	1 959-15

Rates were also obtained from Consulting Engineers working in Lagos, Nigeria. Table 7-7 is a repeat of the previous table, using Consultants rates:

Table 7-7: Bridge Construction Unit Cost (Nigerian Consultants Rates)

DESCRIPTION	UNIT	QUANTITY	RATE (USD)	TOTAL (USD)
30 MPa concrete	m^3	36.8	185-71	6 843-13
High tensile reinforcement	t	5.5	1 250-00	6 875-00
Prestressing	MN.m	310	35-00	10 850-00
Formwork	m^2	85.7	42-85	3 672-45
Driven Piles	m	4.2	2 650-00	11 130-00
			SUBTOTAL / m	39 361-13
			15%	5 904-17
			10%	3 936-11
			SUBTOTAL	49 204-41
			15%	7 380-66
			TOTAL / m	56 585-07
			TOTAL / m^2	1 886-17

The construction cost by using contractors and consultant's rates are very similar. The arithmetical average of the two estimates is **R1 922-66**.

7.1.2.5 Detailed cost estimate from a continental perspective

Lack of competition in Nigeria in the field of large-scale civil engineering projects has lead to an escalation in construction rates, to an extent that the feasibility of many development projects is under pressure. This pre-feasibility study would not be complete in the absence of an investigation into the potential construction costs that would be incurred if major construction companies elsewhere on the continent could participate in the project. This would obviously occur in joint venture with any of the medium and smaller construction companies in Nigeria.

In the following cost estimating exercise, the rates on the Southern African subcontinent for constructing the main components of the proposed bridges were considered. This was followed by a calibration of the rates by considering the regional material and labour differences, with a regional premium on profits associated with perceived increased risks.

Table 7-8: Bridge Construction Unit Cost (Southern African rates)

DESCRIPTION	UNIT	QUANTITY	RATE (USD)	TOTAL (USD)
30 MPa concrete	m^3	36.8	114-28	4 205-50
High tensile reinforcement	t	5.5	785-71	4 321-41
Prestressing	MN.m	310	17-85	5 533-50
Formwork	m^2	85.7	28-57	2 448-45
Driven Piles	m	4.2	1 428-57	5 999-99
			SUBTOTAL / m	22 508-85
Access and drainage			15%	3 376-32
Miscellaneous other items			10%	2 250-89
			SUBTOTAL	28 136-06
Contractor's preliminary and general			15%	4 220-41
			TOTAL / m	32 356-47
			TOTAL / m^2	1 078-55

The table above confirms a 44% regional difference in the estimated construction cost for the proposed bridges (refer to the calculated unit cost of USD 1922-65 in paragraph 2.3, using Nigerian rates). This difference is largely attributed to an expected inequality in profit margins between the regions. In order to limit any differential profit margin, calibrated rates were considered based on regional differences in materials and labour.

Table 7-9: Material and Labour Rates

DESCRIPTION	LAGOS RATE (REF 1) (USD)	LAGOS RATE (REF 2) (USD)	LAGOS RATE (REF 3) (USD)	AVERAG E LAGOS RATE	SOUTHERN AFRICA RATE	RATE DIFFERENCE
Cement	151 / t	97 / t	143 / t	130-33 / t	87-14 / t	+ 33,1%
High tensile reinforcement	714 / t	571 / t	671 / t	652-00 / t	478-57 / t	+ 26,6%
Quarry sand	8-57 / t	11 / t	12-86 / t	10-81 / t	12-14 / t	- 11,0%
Coarse aggregate	23-21 / t	-	22-14 / t	22-69 / t	20-00 / t	+ 11,8%
1000 mm steel casing	-	571 / t	-	571 / t	857 / t	- 50%
Diesel	-	-0-30 / l	-	0-30 / l	0-50 / l	- 40%
Casual labour	-	7 / day	8-57 / day	7-52 / day	7 / day	+ 7,4%
Skilled labour	-	11 / day	10-71 / day	10-90 / day	11 / day	- 0,9%

REF 1 : Marlum Nigeria Ltd

REF 2 : Preliminary Engineering Design of Ejigbo Road and Bridge (October 2003) [Ato Properties Ltd]

REF 3 : Ove Arup Consulting Engineers

The calibration factors for the main components are given below:

- ⇨ Concrete: 1.078 [1 + (0.331 -0.11x2 + .118X3)/6]
- ⇨ Reinforcement: 1.266
- ⇨ Prestressing: 1.456 [1.266 x 1.15]
- ⇨ Formwork: 1,0
- ⇨ Piling: 1.348 [(1.078 + 1.266)/2 x 1.15]

Using the calibration factors, Table 7-10 displays an estimated unit cost for the proposed bridge construction, based on the participation of large contractors outside Nigeria.

Table 7-10: Bridge Construction Unit Cost (Calibrated continental rates)

DESCRIPTION	UNIT	QUANTITY	RATE (USD)	TOTAL (USD)
30 MPa concrete	m^3	36.8	123-19	4 533-39
High tensile reinforcement	t	5.5	994-71	5 470-91
Prestressing	MN.m	310	25.99	8 056-90
Formwork	m^2	85.7	28-57	2 448-45
Driven Piles	m	4.2	1 890-00	7 938-00
			SUBTOTAL / m	28 447-65
Access and drainage			15%	4 267-15
Miscellaneous other items			10%	2 844-77
			SUBTOTAL	35 559-57
Contractor's preliminary and general			15%	5 333-94
Increased regional profit margin			25%	8 889-89
			TOTAL / m	49 784-40
			TOTAL / m^2	1 659-45

7.1.2.6 Initial bridge construction cost estimate summary

Table 7-11 displays a summary of the unit cost rate estimates for constructing the proposed viaduct bridges, as well as a calculated weighted average of the unit rates.

Table 7-11: Summary of Estimated Unit Rates for Bridge Construction

APPROACH	METHOD WEIGHT	OPTIMISTIC SCENARIO	REALISTIC SCENARIO	PESSIMISTIC SCENARIO
Nigeria Literature Search	1	920 USD/m^2	1618 USD/m^2	3560 USD/m^2
Project Database Search	1	2370 USD/m^2	2941 USD/m^2	3398 USD/m^2
Detailed Estimate using Nigerian Rates	5	1731 USD/m^2	1923 USD/m^2	2115 USD/m^2
Detailed Estimate using Calibrated Continental Rates	3	1493 USD/m^2	1659 USD/m^2	1825 USD/m^2
WEIGHTED AVERAGE		1642 USD/m^2	1915 USD/m^2	2301 USD/m^2

[For the two detailed estimation approaches (3rd and 4th lines in the Table), the calculated unit rates was entered in the Realistic Scenario column. Considering a 10% deviation of these values derived the figures for the Pessimistic and Optimistic scenario columns].

In conclusion, it is recommended to use the average realistic scenario unit rate of **USD 1 915 / m^2** per of deck area to estimate the construction cost of all bridge structures for the pre-feasibility stage. Optimisation of this figure and differentiation between the unit rates for different bridge configurations may be implemented during subsequent project stages, when more information becomes available.

7.1.2.7 Periodic and routine maintenance

Maintenance work at bridge structures is characterized by relatively low annual activities, followed by work that is more significant at intervals of approximately 15 years.

The following rates are assumed:

- ⇨ Annual routine maintenance: USD 0.15 / m2
  - ♦ (crack seal, pothole repair, painting)
- ⇨ 15 Year periodic maintenance: USD 60 / m^2
  - ♦ (spalling repair, protective coatings, expansion joint repair)

7.1.3 TOLL PLAZAS

The cost estimate for toll plazas are based on experience with costing of other plazas on the continent, calibrated with a regional cost factor.

The estimated costs are as follows:

Table 7-12: Estimated Toll Plaza Cost

TYPE PLAZA	FIXED COST USD	COST PER TOLL LANE USD
Conventional Mainline Plaza	700 000	450 000
Elevated Mainline Plaza	2 700 000	1 950 000
Conventional Ramp Plaza	-	400 000
Elevated Ramp Plaza	-	1 500 000

Elevated plazas are suspended plazas constructed on reinforced concrete decks over lagoons and marshlands

7.1.4 ROADSIDE FURNITURE

Roadside furniture is miscellaneous items excluded from the estimated road construction cost, including the following:

Table 7-13: Estimated Road Furniture Cost

DESCRIPTION	RATE
Nominal road drainage (surface and subsoil)	USD 10 / m^2
Interchange signs and infrastructure	USD 250 000 / interchange
Street lighting	USD 60 000 / km

7.1.5 COSTING CONCLUSIONS

The estimated costs of the various projects are given per project in further sections of this report.

The construction rates are perceived to be high in relation to comparative costs on other parts of the continent, but are considered realistic given the nature of the information that was available during the compilation of the cost estimates. A general reluctance was experienced from some of the major role players in the Lagos construction industry to make information available to assist with the costing in this report. If some of these entities can be persuaded to participate in subsequent phases of the project, some of the risk element can be reduced and the construction unit costs could be adjusted downwards.

The following items are explicitly excluded from any of the cost items in this report. These items should be taken into account during ensuing stages of this project prior to any financial closure.

- Relocation of existing services
- Expropriation of property
- Supply of bulk services to plazas and roadside furniture
- Detailed design and other professional fees
- Sales tax and import duties

Subsequent investigations and discussions with contractors have revealed that high construction costs are partly attributed to factors that can be controlled if the private sector becomes involved in the funding and provision of infrastructure. These factors are the following:

- Risk of payment default;
- Unreliable supply chain of construction materials;
- Incomplete designs; and

- Lack in a competitive bidding environment.

7.2 Assumed Unit Rates for Infrastructure Projects

Subsequent to the research described in Section 7.1, more information was obtained from:

- Interviews with local contractors;
- Detailed design information; and
- Information from materials investigations.

This information was used to finalize the assumed rates for construction used in the costing of the infrastructure projects. These rates are shown in Table 7-14.

Table 7-14: Assumed Unit Rates for Construction and Maintenance (2004 USD)

Item	Unit	Assumed Unit Rate
CONSTRUCTION		
Layerworks	m^2	$52
Fill - road	m^3	$10
Fill - Retaining walls	m^3	$40
Bridges	m^2	$1,900
New Jersey Barriers	km	$230,000
Retaining walls	m^2	$625
Boundary walls	km	$200,000
Street lighting	km	$60,000
Road furniture	No	$250,000
Drainage	m^2	$10
Mainline plaza	Constant	$420,000
Mainline plaza variable	Per Lane	$270,000
Toll Control Building	Unit	$280,000
MAINTENANCE		
Routine maintenance	m^2	$0.45
Periodic maintenance - @ 10 years	m^2	$16
Periodic maintenance - @ 20 years	m^2	$32
Kerbing	m	$40
Guardrails	km	$100,000

Two additional costing scenarios were nevertheless also investigated for sensitivity purposes; namely:

- ⇨ Estimated cost plus 10%; and
- ⇨ Estimated cost plus 20%

The cost estimates for the various projects are subsequently described.

7.3 COSTING OF OPEBI-MENDE LINK ROAD

7.3.1 ASSUMED NUMBER OF LANES (CAPACITY) DURING CONCESSION PERIOD

Based on the results of the capacity analyses, the assumed number of lanes during the concession is indicated in Table 7-15.

Table 7-15: Assumed Number of Lanes during Concession Period

Scenario	Value of Time	Assumed Number of Lanes for Opebi-Mende Link Road during the Concession Period		
		4-Lanes	6-Lanes	8-Lanes
Realistic Scenario	100 N	2007 to 2037	NA	NA
	200 N	2007 to 2021	2022 to 2037	NA
Pessimistic Scenario	100 N	2007 to 2037	NA	NA
	200 N	2007 to 2037	NA	NA
Optimistic Scenario	100 N	2007 to 2020	2021 to 2028	2029 to 2037
	200 N	2007 to 2017	2018 to 2024	2025 to 2037

7.3.2 CONSTRUCTION PROGRAM AND OPERATION OF TOLL PLAZAS

Give the nature of the project and the structures involved, i.e. interchanges with both Ikorodu Road and Third Axial Bridge, an extended construction period of two years is expected with no potential for any toll revenue during this period.

7.3.3 ESTIMATED COSTS

The estimated construction cost and maintenance cost of the Opebi-Mende Project was subsequently determined as shown in Table 7-16 and Table 7-17 respectively, based on the unit rates reflected in Table 7-14.

Table 7-16: Opebi-Mende Link Road - Estimated Construction Cost (2004 USD)

	4-Lanes	6-Lanes		8-Lanes	
		Incremental Cost	Total Cost	Incremental Cost	Total Cost
Road works	5,492,168	706,050	6,198,218	862,950	7,061,168
Structures	73,494,874	13,397,220	86,892,094	16,374,380	103,266,474
Sub-Total	**78,987,042**	**14,103,270**	**93,090,312**	**17,237,330**	**110,327,642**
Toll Plazas	11,400,000	5,400,000			
Total					

Table 7-17: Opebi-Mende Link Road - Estimated Maintenance Cost (2004 USD)

Routine Maintenance Cost		
4-Lanes	**6-Lanes**	**8-Lanes**
45,868	68,801	103,202
Periodic Maintenance Cost		
Year 10 (4-Lane Road)	**Year 20 (6-Lane Road)**	**Year 30 (8-Lane Road)**
1,630,848	4,892,544	3,669,408

7.4 COSTING OF LEKKI CORRIDOR

7.4.1 ASSUMED NUMBER OF LANES (CAPACITY) DURING CONCESSION PERIOD

Based on the results of the capacity analyses, the assumed number of lanes during the concession period is indicated in Table 6-41 and Table 6-42.

7.4.2 CONSTRUCTION PROGRAM AND OPERATION OF TOLL PLAZAS

The assumed construction program is showed in Table 7-18. According to this program, construction works can start simultaneously on the Epe Expressway and the Coastal Road (the same contractor or different contractors). However, it should be avoided to work simultaneously on the first 6km of both routes from an accommodation of traffic point of view. It is hence recommended to start improving Epe Expressway from km 6.0 to km 20 while the first section (km 0 to km 6) of the Coastal Freeway is constructed. During this time, the construction of the structural elements at the Falomo Bridge can also take place.

This program will allow the opening of the Epe Expressway Chevron Plaza (Epe Toll Plaza 2) and the Coastal Kuramo Plaza (Coastal Toll Plaza 1) six months before the start of operations, i.e. after 18 months.

Table 7-18: Construction and Start of Toll Operation Program for Lekki Corridor

			SEMESTERS FROM START OF CONSTRUCTION				
			FIRST 6-MNTHS	SECOND 6-MNTHS	THIRD 6-MNTHS	FOURTH 6-MNTHS	FIFTH 6-MNTHS
CONSTRUCTION OF EPE EXPRESSWAY							
EPE EXPRESS-WAY	On-Ramp Falomo Bridge		↔	↔			
	Km 0	Km 6			↔	↔	
	Km 6	Km 47.5	↔	↔			
CONSTRUCTION OF COASTAL ROAD							
COASTAL	Km 0	Km 6	↔	↔			
	Admiralty Link Lekki Peninsula Link		↔	↔			
	Kuramo Plaza		↔	↔			
	Km 6	Km 20			↔	↔	
	Gbari Link Chevron Link 4th Mainland Link				↔	↔	
	Chevron Plaza				↔	↔	
TOLL OPERATIONS: OPENING OF PLAZAS							
Epe Maroko Toll Plaza							→
Coastal: Kuramo Toll Plaza					▪▪▪▪	→	→
Epe: Chevron Toll Plaza					▪▪▪▪	→	→
Coastal Chevron Toll Plaza							→

7.4.3 ESTIMATED COSTS

The estimated construction and maintenance cost of the Lekki Corridor was subsequently determined as shown in Table 7-19 and Table 7-20 respectively, based on the unit rates reflected in Table 7-14.

Table 7-19: Estimated Construction Cost of Lekki Corridor (2004 USD)

Description		Roads			Structures		
		Initial	Upgrade 1	Upgrade 2	Initial	Upgrade 1	Upgrade 2
Epe Xway	E: km0-km6.5	11,782,680	0	0	10,774,210	0	0
	E: km6.5-20	25,796,340	0	0	1,900,000	0	0
	E: km20-47.5	6,607,200	6,056,600	0	0	1,900,000	0
Subtotal		44,186,220	6,056,000	0	12,674,210	1,900,000	0
Coastal Freeway	C: km-0.5-6.5	25,264,654	2,459,106	0	18,390,100	10,077,600	0
	C: km6.5-20	19,838,550	16,626,788	0	950,000	15,116,400	0
	C: km20-47.5	0	36,565,870	0	0	950,000	0
	Alternative C: km20-47.5	(0)	(36,565,870)	(32,836,600)	(0)	(950,000)	(20,155,200)
Subtotal		45,603,204	55,651,764	0	19,340,100	26,144,000	0
Links	L: 1[ST] Section	3,024,300	0	0	0	0	0
	L: 2[nd] Section	6,173,550	7,435,800	0	0	0	0
	L: 3[rd] Section	0	13,848,120	0	0	0	0
	Alternative L: 3[rd] Section	(0)	(13,848,120)	(16,679,520)	(0)	(0)	(0)
Subtotal		9,197,850	21,283,920	0	0	0	0
		98,987,274	82,992,284	0	32,014,310	28,044,000	0

Table 7-20: Estimated Maintenance Cost of Lekki Corridor (2004 USD)

Description		Routine Maintenance			Periodic Maintenance		
		Initial	Upgrade 1	Upgrade 2	Year 10 (Initial)	Year 20 (Initial plus Upgrade 1)	Year 30 (Initial plus Upgrade 2)
Epe Xway	E: km0-km6.5	84,078	0	0	2,989,440	5,978,880	2,989,440
	E: km6.5-20	187,232	0	0	6,657,120	13,314,240	6,657,120
	E: km20-47.5	185,828	185,828	0	6,607,200	13,214,400	6,607,200
Coastal Freeway	C: km-0.5-6.5	85,825	103,673	0	3,051,552	7,372,320	3,686,160
	C: km6.5-20	79,088	148,938	0	2,812,000	10,591,168	5,295,584
	C: km20-47.5	0	147,357	0	0	5,239,360	10,478,720
	Alternative C: km20-47.5	(0)	(147,357)	(286,205)	(0)	(5,239,360)	(15,718,080)
Links	L: 1[St] Section	16,830	0	0	598,400	1,196,800	598,400
	L: 2[Nd] Section	37,868	75,735	0	1,346,400	5,385,600	2,692,800
	L: 3[Rd] Section	0	84,942	0	0	3,020,160	6,040,320
	Alternative L: 3[Rd] Section	(0)	(84,942)	(169,884)	(0)	(3,020,160)	(9,060,480)

7.5 COSTING OF SOUTHERN BYPASS

7.5.1 ASSUMED NUMBER OF LANES (CAPACITY) DURING CONCESSION PERIOD

Based on the results of the capacity analyses, the assumed number of lanes during the concession period is indicated in Table 7-21:

Table 7-21: Assumed Number of Lanes during Concession Period

	Capacity in number of lanes	
	4-Lanes	**6-Lanes**
Southern Bypass	2007 to 2016 First 10-years	2016 to 2037 Second 20-years

7.5.2 CONSTRUCTION PROGRAM AND OPERATION OF TOLL PLAZAS

Give the nature of the project and the structures involved, i.e. directionals between eastern Ring Road and the new Bypass, the construction of reinforced earth walls along the total length of the project, and the construction works under high traffic flow conditions, an extended construction period of two years is expected with no potential for any toll revenue during this period.

7.5.3 ESTIMATED COSTS

The estimated construction and maintenance cost of the Southern Bypass was subsequently determined as shown in Table 7-22, based on the unit rates reflected in Table 7-14.

Table 7-22: Estimated Costs of the Southern Bypass (2004 USD)

	Stage (number of lanes)	
	4-Lane Cross-section	**6-Lane Cross-section**
Construction cost	$108,744,347	$122,406,347
Routine maintenance cost per km	$71,487	$81,567
10-year and 30-year Periodic maintenance cost per km	$2,541,776	$2,900,176
20-year Periodic maintenance cost per km	$5,083,552	$5,800,352

8 FINANCIAL MODELLING

8.1 INTRODUCTION

The FINCON financial model is a non-recourse project-financing model that was developed to determine the viability of infrastructure concession projects. This model calculates all the revenue and expenditure cash flow streams in detail based on comprehensive technical input. It was however never intended for fine-tuning of financial input/output, i.e. type of financial instruments to be used or the terms and conditions of financing. However, the level of sophistication included in the model probably results in output which are within ±10% of what can be obtained with a more detailed financial model.

The FINCON model calculates MOEs such as internal rate of return on equity (ROE), net present values (NPV) for project and for equity investors, and debt-to-service cover ratio's (DSCR), etc.

The most important parameter however is the ROE and NPV since it is assumed that DSCRs – if not acceptable - can be improved through financial engineering, i.e. by sculpting the repayment profiles.

8.2 ASSUMPTIONS

The key financial input in the model is reflected in Table 8-1. This input was obtained or determined in conjunction with Standard Bank from South Africa, which are the lead financial advisors for this project.

Table 8-1: Financial Input Parameters

CONCESSION	
Concession Start	2007
Concession Ends	2036
Concession Period	30 years
ECONOMIC INPUT PARAMETERS	
Exchange Rate	140 Naira
Weakening in Exchange Rate	12.5% pa
CPI Local	15.0% pa
CPI USD based	2.5% pa
Discount Rate	20%
Company Tax Rate	32%

FUNDING STRUCTURE		
INSTRUMENT	DISTRIBUTION	
Local Equity	16%	
Local Subordinate Debt	12%	
Foreign Subordinate Debt	12%	
Local Senior Debt	42%	
Foreign Senior Debt	18%	
TERMS AND CONDITIONS		
DEBT	TENOR	NOMINAL RATE
Local Subordinate Debt	10 years	24%
Foreign Subordinate Debt	10 years	12.5%
Local Senior Debt	9 years	20%
Foreign Senior Debt	10 years	9%
INSTRUMENT	CAPITALIZE INTEREST	REPAYMENT PRINCIPAL
All Debt Instruments	First 2 years	After year 3
CAPITAL ALLOWANCES		
ITEM	ALLOWANCE	% OF WORKS
Permanent Works	4% pa	30%
Non-Permanent Works	12.5%pa	70%
% Company Profit subject to Capital Allowances		66.7%
CAPITAL AND MAINTENANCE RESERVE FUNDS		
Nominal Rate	16%	
	PROVISION BEFORE EXPENDITURE	
5-Years	10%	
4-Years	15%	
3-Years	25%	
2-Years	25%	
1-Year	25%	

8.3 RESULTS OF FINANCIAL MODELLING

The results of the financial modelling are subsequently reported in table format. These results include the following scenarios:

- ROE (real rate) for toll tariffs of 100 Naira for Class I vehicles;
- Required toll tariff to obtain a ROE (real rate) of 16%;
- ROE for two high cost scenarios, namely +10% and +20%;

- ROE for realistic, pessimistic, and optimistic scenarios (in terms of traffic forecasting);
- ROE for a value of time (VOT) of 100 Naira per hour and a VOT of 200 Naira per hour (Opebi-Mende Link); and
- ROE for high capex and low capex scenarios.

In addition, the total initial capex, as well as the total required road improvement capex during the concession period is reported for every case, as well as the net present value (NPV) of the return to equity investors.

These results are subsequently reported separately for the Opebi-Mende Link, the Lekki Corridor, and the Lekki Corridor with the Southern Bypass.

The detailed results of the financial model for the realistic scenario are attached in **Annexure B**. Table 9-1 serves as a reference to the table numbers.

8.3.1 RESULTS OF OPEBI-MENDE LINK ROAD

The results of the financial model are shown in Table 8-2. Table 8-3 shows the sensitivity of the project for a 10% and 20% increase in costs.

Table 8-2: Results of Financial Model: Opebi-Mende Link

SCENARIO		REALISTIC SCENARIO	PESSIMISTIC SCENARIO	OPTIMISTIC SCENARIO
VOT = 100 NAIRA	INITIAL CAPEX (USD millions)	USD 91.8m	USD 91.8m	USD 92.9m
	ROAD IMPROVEMENT CAPEX DURING CONCESSION (USD millions)	USD 90.6m	USD 90.6m	USD 122.6m
	LIMITED TOLL TARIFF (100 N, 19 N, 19 N) SCENARIO			
	ROE	Negative	Negative	Negative
	NPV	USD -12.5m	USD -12.5m	USD -12.7m
	MINIMUM REAL ROE (16%) SCENARIO			
	Toll Tariffs (Toll Class I):			
	- Mainline	237 N	281 N	187 N
	- Ramp 1	44 N	52 N	35 N
	- Ramp 2	44 N	52 N	35 N
	ROE	16%	16%	16%
	NPV	USD 90.9m	USD 69.9m	USD 106.1m

SCENARIO		REALISTIC SCENARIO	PESSIMISTIC SCENARIO	OPTIMISTIC SCENARIO
VOT = 200 NAIRA	INITIAL CAPEX (USD millions)	USD 96.1m	USD 95.0m	USD 97.2m
	ROAD IMPROVEMENT CAPEX DURING CONCESSION (USD millions)	USD 103.9m	USD 90.6m	USD 125.3m
	LIMITED TOLL TARIFF (100 N, 19 N, 19 N) SCENARIO			
	ROE	Negative	Negative	Negative
	NPV	USD –12.7m	USD –13.0m	USD 16.6m
	MINIMUM REAL ROE (16%) SCENARIO			
	Toll Tariffs (Toll Class I):			
	- Mainline	159 N	177 N	140 N
	- Ramp 1	30 N	33 N	26 N
	- Ramp 2	30 N	33 N	26 N
	ROE	16.0%	16.0%	16.0%
	NPV	USD 85.8m	USD 67.8m	USD 100.9m

Table 8-3: Required Toll Tariffs for 16% ROE (VOT = 200 N): Sensitivity of Opebi-Mende Link for Costs

SCENARIO		REALISTIC SCENARIO	PESSIMISTIC SCENARIO	OPTIMISTIC SCENARIO
ESTIMATED COSTS PLUS 10%	INITIAL CAPEX (USD millions)	USD 105.7	USD 104.5	USD 106.9
	ROAD IMPROVEMENT CAPEX DURING CONCESSION (USD millions)	USD 114.5m	USD 99.7m	USD 138.6m
	Toll Tariffs (Toll Class I):			
	- Mainline	172 N	192 N	153 N
	- Ramp 1	32 N	36 N	28 N
	- Ramp 2	32 N	36 N	28 N
	NPV	USD 100.6m	USD 79.9m	USD 121.1m
ESTIMATED COSTS PLUS 20%	INITIAL CAPEX (USD millions)	USD 115.3m	USD 114.0m	USD 116.6m
	ROAD IMPROVEMENT CAPEX DURING CONCESSION (USD millions)	USD 125.2m	USD 108.7m	USD 152.1m
	Toll Tariffs (Toll Class I):			
	- Mainline	186 N	208 N	165 N
	- Ramp 1	35 N	39 N	31 N
	- Ramp 2	35 N	39 N	31 N
	NPV	USD 109.2m	USD 87.6m	USD 130.9m

8.3.2 RESULTS OF LEKKI CORRIDOR

The results of the financial model are shown in Table 8-4. Table 8-5 shows the sensitivity of the project for a 10% and 20% increase in costs.

Table 8-4: Results of Financial Model: Lekki Corridor

SCENARIO		REALISTIC SCENARIO	PESSIMISTIC SCENARIO	OPTIMISTIC SCENARIO
LOW FUTURE CAPEX	INITIAL CAPEX (USD millions)	USD 156.3m	USD 155.2m	USD 157.3m
	ROAD IMPROVEMENT CAPEX DURING CONCESSION (USD millions)	USD 376.8m	USD 376.8m	USD 376.8m
	LIMITED TOLL TARIFF (100 N) SCENARIO			
	ROE	16.3%	14.5%	18.0%
	NPV	USD 199.0m	USD 146.2m	USD 263.1m
	MINIMUM REAL ROE (16%) SCENARIO			
	Toll Tariffs (Toll Class I):			
	- Mainline		106 N	
	NPV		USD 171.3m	
HIGH FUTURE CAPEX	INITIAL CAPEX (USD millions)	USD 156.3m		USD 157.3m
	ROAD IMPROVEMENT CAPEX DURING CONCESSION (USD millions)	USD 448.6m		USD 448.6m
	LIMITED TOLL TARIFF (100 N) SCENARIO			
	ROE	15.0%		17%
	NPV	USD 171.2m		USD 235.3m
	MINIMUM REAL ROE (16%) SCENARIO			
	Toll Tariffs (Toll Class I):			
	- Mainline	104 N		
	NPV	USD 189.6m		

Table 8-5: Required Toll Tariffs for ROE = 16%: Sensitivity of Lekki Corridor for Costs

SCENARIO		REALISTIC SCENARIO	PESSIMISTIC SCENARIO	OPTIMISTIC SCENARIO
LOW FUTURE CAPEX COST ESTI-MATE PLUS 10%	INITIAL CAPEX (USD millions)	USD 171.9m	USD 170.7m	USD 173.1m
	ROAD IMPROVEMENT CAPEX DURING CONCESSION (USD millions)	USD 414.5m	USD 414.5m	USD 414.5m
	Toll Tariffs (Toll Class I):			
	- Mainline	108 N	115 N	99 N
	NPV	USD 212.1m	USD 187.0m	USD 233.5m
LOW FUTURE CAPEX COST ESTI-MATE PLUS 20%	INITIAL CAPEX (USD millions)	USD 187.5m	USD 186.2m	USD 188.8m
	ROAD IMPROVEMENT CAPEX DURING CONCESSION (USD millions)	USD 452.2m	USD 452.2m	USD 452.2m
	Toll Tariffs (Toll Class I):			
	- Mainline	116 N	125 N	108 N
	NPV	USD 229.6m	USD 203.4m	USD 255.0m
HIGH FUTURE CAPEX COST ESTI-MATE PLUS 10%	INITIAL CAPEX (USD millions)	USD 171.9m		USD 173.1m
	ROAD IMPROVEMENT CAPEX DURING CONCESSION (USD millions)	USD 493.5m		USD 493.5m
	Toll Tariffs (Toll Class I):			
	- Mainline	113 N		105 N
	NPV	USD 207.6m		USD 233.6m
HIGH FUTURE CAPEX COST ESTI-MATE PLUS 20%	INITIAL CAPEX (USD millions)	USD 187.5m		USD 188.8m
	ROAD IMPROVEMENT CAPEX DURING CONCESSION (USD millions)	USD 538.3m		USD 538.3m
	Toll Tariffs (Toll Class I):			
	- Mainline	123 N		113 N
	NPV	USD 226.3m		USD 253.2m

8.3.3 RESULTS OF LEKKI CORRIDOR WITH SOUTHERN BYPASS

The results of the financial model are shown in Table 8-6. Table 8-7 shows the sensitivity of the project for a 10% and 20% increase in costs.

Table 8-6: Results of Financial Model: Lekki Corridor With Southern Bypass

SCENARIO		REALISTIC SCENARIO	PESSIMISTIC SCENARIO	OPTIMISTIC SCENARIO
LOW FUTURE CAPEX	INITIAL CAPEX (USD millions)	USD 285.9m	USD 283.7m	USD 288.0m
	ROAD IMPROVEMENT CAPEX DURING CONCESSION (USD millions)	USD 530.4m	USD 530.4m	USD 530.4m
	LIMITED TOLL TARIFF (100 N) SCENARIO			
	ROE	Negative	Negative	12.5%
	NPV	USD 176.0m	USD 109.3m	USD 252.9m
	MINIMUM REAL ROE (16%) SCENARIO			
	Toll Tariffs (Toll Class I):			
	- Ozumba	11 N	11 N	10 N
	- Adesola	37 N	40 N	34 N
	- Kuramo Ramps	170 N	183 N	158 N
	- Mainline	127 N	137 N	118 N
	NPV	USD 350.6m	USD 315.0m	USD 387.9m
HIGH FUTURE CAPEX	INITIAL CAPEX (USD millions)	USD 285.9m	USD 283.7m	USD 288.0m
	ROAD IMPROVEMENT CAPEX DURING CONCESSION (USD millions)	USD 584.7m	USD 584.7m	USD 584.7m
	LIMITED TOLL TARIFF (100 N) SCENARIO			
	ROE	Negative	Negative	11.8%
	NPV	USD 154.8m	USD 88.1m	USD 231.7m
	MINIMUM REAL ROE (16%) SCENARIO			
	Toll Tariffs (Toll Class I):			
	- Ozumba	11 N	12 N	10 N
	- Adesola	38 N	41 N	35 N
	- Kuramo Ramps	174 N	187 N	162 N
	- Mainline	130 N	140 N	121 N
	NPV	USD 347.8m	USD 309.9m	USD 387.2m

Table 8-7: Required Toll Tariffs for ROE = 16%: Sensitivity of Lekki Corridor With Southern Bypass for Costs

SCENARIO		REALISTIC SCENARIO	PESSIMISTIC SCENARIO	OPTIMISTIC SCENARIO
LOW FUTURE CAPEX COST ESTI-MATE PLUS 10%	INITIAL CAPEX (USD millions)	USD 314.5m	USD 312.1m	USD 316.9m
	ROAD IMPROVEMENT CAPEX DURING CONCESSION (USD millions)	USD 583.4m	USD 583.4m	USD 583.4m
	Toll Tariffs (Toll Class I):			
	- Ozumba	11 N	12 N	11 N
	- Adesola	40 N	43 N	37 N
	- Kuramo Ramps	185 N	200 N	172 N
	- Mainline	139 N	150 N	129 N
	NPV	USD 382.5m	USD 347.0m	USD 423.8m
LOW FUTURE CAPEX COST ESTI-MATE PLUS 20%	INITIAL CAPEX (USD millions)	USD 343.1m	USD 340.5m	USD 345.7m
	ROAD IMPROVEMENT CAPEX DURING CONCESSION (USD millions)	USD 636.4m	USD 636.4m	USD 636.4m
	Toll Tariffs (Toll Class I):			
	- Ozumba	12 N	13 N	12 N
	- Adesola	44 N	47 N	41 N
	- Kuramo Ramps	201 N	216 N	187 N
	- Mainline	150 N	162 N	140N
	NPV	USD 416.4m	USD 376.6m	USD 464.1m
HIGH FUTURE CAPEX COST ESTI-MATE PLUS 10%	INITIAL CAPEX (USD millions)	USD 314.5 m	USD 312.1m	USD 316.9m
	ROAD IMPROVEMENT CAPEX DURING CONCESSION (USD millions)	USD 643.1m	USD 643.1m	USD 643.1m
	Toll Tariffs (Toll Class I):			
	- Ozumba	12 N	13 N	11 N
	- Adesola	41 N	44 N	38 N
	- Kuramo Ramps	190 N	204 N	177 N
	- Mainline	142 N	153 N	132 N
	NPV	USD 381.3m	USD 340.7m	USD 425.0m
HIGH FUTURE CAPEX COST ESTI-MATE PLUS 20%	INITIAL CAPEX (USD millions)	USD 343.1m	USD 340.5m	USD 345.7m
	ROAD IMPROVEMENT CAPEX DURING CONCESSION (USD millions)	USD 701.6m	USD 701.6m	USD 701.6m
	Toll Tariffs (Toll Class I):			
	- Ozumba	13 N	14 N	12 N
	- Adesola	45 N	48 N	42 N
	- Kuramo Ramps	206 N	221 N	192 N
	- Mainline	154 N	165 N	144 N
	NPV	USD 414.0m	USD 370.5m	USD 464.1m

9 CONCLUSIONS AND RECOMMENDATIONS

The financial results are summarised in Table 9-2. These results are hence discussed separately for the various projects.

9.1 OPEBI-MENDE LINK ROAD

The following is concluded:

1. The required capital cost for this project is USD 96.1 million for the initial construction of 3.680 km of 4-lane freeway including two partial systems interchanges, one mainline toll plaza, and two ramp toll plazas.

2. The demand simulation for the Opebi-Mende Link Road was based on generally accepted transportation planning methodology and techniques, which have included the calibration of the model with extensive field data.

3. The result of these transportation-planning studies, i.e. the expected demand, was verified based on the expected benefits in terms of reduced travel times (higher average speeds), and savings in fuel cost.

4. A value of time (VOT) of 200 Naira per hour is applicable. See the discussion in Section 2.

5. The required toll tariff for Class I vehicles for a real ROE of 16% is 159 Naira per trip for the realistic scenario. The toll tariff for the optimistic scenario is 140 Naira per hour. An increase of 10% and 20% in the estimated costs will result in toll tariffs of 172 Naira and 186 Naira respectively.

6. The required toll tariffs (realistic scenario) translate to high unit rates (per km) based on the short distance of 3.680 km, i.e. 31 US cents per km. This compares to an average SA rate of 5 US cents per km for Class I vehicles.

7. Commuters will have to pay for two trips per day, which translates to 318 Naira per day, and ±7,000 Naira per month (22 days).

8. The surrounding road network is generally congested. The proposed toll link will therefore only provide an improvement in travel conditions for a very short distance of the total trip lengths. The transportation model has furthermore shown that it is difficult to obtain access to the new link (due to congestion on the links that connects to the new link) and some benefits are lost when traffic has to divert to use this new linkage.

9. Several alternatives routes are available and are currently being used by the traffic in the area. It would thus be very easy to avoid the new road link – i.e. potential low attraction.

10. Assuming a value of time of 200 Naira per hour, translates to a required average time saving of 48 minutes (159/200 X 60 minutes) in order to justify the tariff based on the cost of travel time alone. Since the average trip times in this area is in the order of one hour (average of 54 minutes from SP surveys), the required savings is impossible to obtain.

11. It is thus concluded that the construction of the Opebi-Mende Link as a concession is a risky undertaking with relatively high toll tariffs and a high risk of diversion. This project is not viable, as a stand-alone project and will require a subsidy.

9.2 LEKKI CORRIDOR

The following is concluded:

1. The required capital cost for this project is USD 156.3 million for the initial construction of the following:
   - ⇨ New construction of 6.5km 4-lane freeway;
   - ⇨ New construction of 13.5km two-lane rural highway;
   - ⇨ New construction of 1.7km 4-lane connector roads;
   - ⇨ New construction of 7.65km 2-lane connector roads;
   - ⇨ Upgrading of 20km 4-lane road to six-lanes including the provision of pedestrian bridges, public transport facilities and street lighting;
   - ⇨ Rehabilitation of 27.5 km 4-lane road; and
   - ⇨ Construction of four mainline toll plazas.

2. The demand simulation for the Lekki Corridor was based on generally accepted transportation planning methodology and techniques, which have included the calibration of the model with extensive field data.

3. The result of these transportation-planning studies, i.e. the expected demand, was verified based on the expected benefits in terms of reduced travel times (higher average speeds), and savings in fuel cost.

4. The construction of the High Future Capex option for the Lekki Corridor is recommended; i.e. this includes the upgrading of the section of the Coastal Freeway between the 4th Mainland Bridge and Eleko Beach to a four-lane freeway in year 20 of the concession.

5. Toll Tariffs in the range of 100 N to 110 N will result in a real ROE of 16% pa, which translates to average toll rates of approximately 6 US cent per km for Class I vehicles (This compares to an average SA rate of 5 US cents per km for Class I vehicles.)

6. The weighted average utilization of the number of toll plazas in the corridor is about 2.0 per motorist.

7. The risks of this project is low:

   ⇨ Both the existing Epe Expressway and the new Coastal Freeway will be tolled;

   ⇨ Opportunities for diversion is low given that the supporting road network is poorly developed and consists mainly of local streets through township developments – it can thus be expected that only short distance local trips will avoid the toll plazas;

   ⇨ The Lekki Corridor is an established high growth area that supports commercial, business, and medium-to-high income residential development;

   ⇨ The development and implementation of improvements in the Lekki Corridor can be phased as is shown in Table 6-42 – it is thus possible to delay the implementation of future upgrading if the actual traffic growth is lower than the forecasts;

8. The implementation of the concession will result in substantial benefits as is shown in this report. Without the implementation of this concession, the future growth in this corridor will slow down dramatically and development will be constrained by the limited road capacity.

9. It is hence concluded that this project is viable as a toll concession at affordable toll rates with the recommended improvements shown in Table 6-42 and the implementation program shown in Table 7-18.

Table 6-42: Recommended Improvement during Concession Period – High Capex Scenario

<table>
<tr><th colspan="3">Period from start of concession</th><th>10 Years</th><th>15 Years</th><th>20 Years</th><th>30 Years</th></tr>
<tr><th colspan="3">Year end</th><th>2016</th><th>2021</th><th>2026</th><th>2036</th></tr>
<tr><td rowspan="3">Epe Express-way</td><td>Falomo to Lekki</td><td>1</td><td colspan="4">6-lane Urban Arterial</td></tr>
<tr><td>Lekki to 4th Mainland</td><td>2</td><td colspan="4">6-lane Urban Arterial</td></tr>
<tr><td>4th Mainland to Eleko Beach</td><td>3</td><td>4-lane Rural Arterial</td><td colspan="3">4 Rural Arterial (Upgrade)</td></tr>
<tr><td rowspan="3">Coastal Freeway</td><td>Akin Adesola to Lekki</td><td>1</td><td colspan="2">4-lane Freeway</td><td colspan="2">6-lane Freeway</td></tr>
<tr><td>Lekki to 4th Mainland</td><td>2</td><td>2-lane Rural Highway</td><td colspan="3">4-lane Freeway</td></tr>
<tr><td>4th Mainland to Eleko Beach</td><td>3</td><td>None</td><td colspan="2">2-lane Rural Highway</td><td>4-lane Freeway</td></tr>
<tr><td rowspan="3">Links</td><td>Admiralty + Lekki</td><td>1</td><td colspan="4">4-lane Urban Arterial</td></tr>
<tr><td>Gbari + Chevron + 4th Mainland</td><td>2</td><td>2-lane Urban Arterial</td><td colspan="3">4-lane Urban Arterial</td></tr>
<tr><td>Sangotedo + 3x New Town + Eleko Beach</td><td>3</td><td>None</td><td colspan="2">2-lane Urban Arterial</td><td>4-lane Urban Arterial</td></tr>
</table>

Table 7-18: Construction and Start of Toll Operation Program for Lekki Corridor

			SEMESTERS FROM START OF CONSTRUCTION				
			FIRST 6-MNTHS	**SECOND 6-MNTHS**	**THIRD 6-MNTHS**	**FOURTH 6-MNTHS**	**FIFTH 6-MNTHS**
CONSTRUCTION OF EPE EXPRESSWAY							
EPE EXPRESS-WAY	On-Ramp Falomo Bridge		↔	↔			
	Km 0	Km 6			↔	↔	
	Km 6	Km 47.5	↔	↔			
CONSTRUCTION OF COASTAL ROAD							
COASTAL	Km 0	Km 6	↔	↔			
	Admiralty Link Lekki Peninsula Link		↔	↔			
	Kuramo Plaza		↔	↔			
	Km 6	Km 20			↔	↔	
	Gbari Link Chevron Link 4th Mainland Link				↔	↔	
	Chevron Plaza				↔	↔	
TOLL OPERATIONS: OPENING OF PLAZAS							
Epe Maroko Toll Plaza							→
Coastal: Kuramo Toll Plaza					- - -	→	→
Epe: Chevron Toll Plaza					- - -	→	→
Coastal Chevron Toll Plaza							→

9.3 LEKKI CORRIDOR WITH SOUTHERN BYPASS

The following is concluded:

1. The required capital cost for the Southern Bypass is USD 129.6 million for the initial construction of the following:
   - ⇨ New construction of 3.375km 4-lane freeway;
   - ⇨ New construction of 3.375km 4-lane frontage roads;
   - ⇨ New construction of 0.8km directionals;
   - ⇨ Construction of three underpasses and two interchanges; and
   - ⇨ Construction of two ramp plazas.
2. The demand simulation for the Lekki Corridor with the Southern Bypass was based on generally accepted transportation planning methodology and techniques, which have included the calibration of the model with extensive field data.
3. The result of these transportation-planning studies, i.e. the expected demand, was verified based on the expected benefits in terms of reduced travel times (higher average speeds), and savings in fuel cost.
4. Toll Tariffs in the range of 130 N to 140 N – in the Lekki Corridor which includes the Southern Bypass - will result in a real ROE of 16% pa, which translates to average toll rates of approximately 8 US cent per km for Class I vehicles (This compares to an average SA rate of 5 US cents per km for Class I vehicles.)
5. The implementation of the Southern Bypass will contribute significantly to reduce congestion on the Lagos Island, Ikoyi, and the Victoria Island:
   - ⇨ Traffic movements between the Mainland, Lagos Island/Ikoyi, and Victoria Island can currently use only one of two bridges to cross the Five Cowrie Creek, namely Ahmadu Bello Way Bridge and Falomo Bridge (Kingsway Road);
   - ⇨ Both routes, Ahmadu Bello Way and Kingsway Road (Falomo Bridge), are heavily congested during peak periods;
   - ⇨ The construction of the proposed Southern Bypass on the alignment of Ahmadu Bello Way will provide additional north-south capacity transversing Lagos Island/Ikoyi and crossing the Five Cowrie Creek;

- ⇨ The construction of the directionals between the eastern Ring Road and the new Southern Bypass will enable the optimum utilization of a facility which is currently under utilized, i.e. the eastern section of the Ring Road;

- ⇨ The construction of the Southern Bypass will assist to distribute more traffic to the new Coastal Freeway over the most western section of the Coastal Freeway, which will relieve congestion on Maroko Road and Akin Adesola Road.

6. The implementation of this project will result in substantial benefits in terms of the Mainland-Victoria Island/Ikoyi-Victoria Island linkage and the optimum utilization of the new Coastal Freeway. Without the implementation of this project, the full benefits of the Lekki Corridor cannot be realized.

7. It is hence concluded that this project is viable as a toll concession and should be pursued as a logical extension of the implementation of the Lekki Corridor.

Table 9-1: Reference to Annexure B

SCENARIO	CONDITION	OPEBI-MENDE LINK ROAD			LEKKI CORRIDOR			LEKKI CORRIDOR WITH BYPASS		
		Realistic	Pessimistic	Optimistic	Realistic	Pessimistic	Optimistic	Realistic	Pessimistic	Optimistic
VOT = 100	Toll Tariff = 100 N	Annex 1	Annex 2	Annex 3	NA	NA	NA	NA	NA	NA
	ROE (real) = 16%	Annex 4	Annex 5	Annex 6	NA	NA	NA	NA	NA	NA
VOT = 200	Toll Tariff = 100 N	Annex 7	Annex 8	Annex 9	NA	NA	NA	NA	NA	NA
	ROE (real) = 16%	Annex 10	Annex 11	Annex 12	NA	NA	NA	NA	NA	NA
Cost +10%	ROE (real) = 16%	Annex 13	Annex 14	Annex 15	NA	NA	NA	NA	NA	NA
Cost +20%	ROE (real) = 16%	Annex 16	Annex 17	Annex 18	NA	NA	NA	NA	NA	NA
Low Future Capex	Toll Tariff = 100 N	NA	NA	NA	Annex 19	Annex 20	Annex 21	Annex 36	Annex 37	Annex 38
	ROE (real) = 16%	NA	NA	NA		Annex 22		Annex 39	Annex 40	Annex 41
High Future Capex	Toll Tariff = 100 N	NA	NA	NA	Annex 23		Annex 24	Annex 42	Annex 43	Annex 44
	ROE (real) = 16%	NA	NA	NA	Annex 25			Annex 45	Annex 46	Annex 47
Low Future Capex and Cost +10%	ROE (real) = 16%	NA	NA	NA	Annex 26	Annex 27	Annex 28	Annex 48	Annex 49	Annex 50
Low Future Capex and Cost +20%	ROE (real) = 16%	NA	NA	NA	Annex 29	Annex 30	Annex 31	Annex 51	Annex 52	Annex 53
High Future Capex and Cost +10%	ROE (real) = 16%	NA	NA	NA	Annex 32		Annex 33	Annex 54	Annex 55	Annex 56
High Future Capex and Cost +20%	ROE (real) = 16%	NA	NA	NA	Annex 34		Annex 35	Annex 57	Annex 58	Annex 59

Table 9-2: Summary of Financial Results

SCENARIO	CONDITION	OPEBI-MENDE LINK ROAD			LEKKI CORRIDOR			LEKKI CORRIDOR WITH BYPASS		
		Realistic	Pessimistic	Optimistic	Realistic	Pessimistic	Optimistic	Realistic	Pessimistic	Optimistic
VOT = 100	Toll Tariff = 100 N	ROE = negative	ROE = negative	ROE = negative	NA	NA	NA	NA	NA	NA
	ROE (real) = 16%	237 Naira	281 Naira	187 Naira	NA	NA	NA	NA	NA	NA
VOT = 200	Toll Tariff = 100 N	ROE = negative	ROE = negative	ROE = negative	NA	NA	NA	NA	NA	NA
	ROE (real) = 16%	159 Naira	177 Naira	140 Naira	NA	NA	NA	NA	NA	NA
Cost +10%	ROE (real) = 16%	172 Naira	192 Naira	153 Naira	NA	NA	NA	NA	NA	NA
Cost +20%	ROE (real) = 16%	186 Naira	208 Naira	165 Naira	NA	NA	NA	NA	NA	NA
Low Future Capex	Toll Tariff = 100 N	NA	NA	NA	ROE = 16.3%	ROE = 14.5%	ROE = 18.0%	ROE = negative	ROE = negative	ROE = 12.5%
	ROE (real) = 16%	NA	NA	NA		106 Naira		127 Naira	137 Naira	118 Naira
High Future Capex	Toll Tariff = 100 N	NA	NA	NA	ROE = 15.0%		ROE = 17.0%	ROE = negative	ROE = negative	ROE = 11.8%
	ROE (real) = 16%	NA	NA	NA	104 Naira			130 Naira	140 Naira	121 Naira
Low Future Capex and Cost +10%	ROE (real) = 16%	NA	NA	NA	108 Naira	115 Naira	99 Naira	139 Naira	150 Naira	129 Naira
Low Future Capex and Cost +20%	ROE (real) = 16%	NA	NA	NA	116 Naira	125 Naira	108 Naira	150 Naira	162 Naira	140 Naira
High Future Capex and Cost +10%	ROE (real) = 16%	NA	NA	NA	113 Naira		105 Naira	142 Naira	153 Naira	132 Naira
High Future Capex and Cost +20%	ROE (real) = 16%	NA	NA	NA	123 Naira		113 Naira	154 Naira	165 Naira	144 Naira

ANNEXURE A

ANNEXURE B