GOVERNMENT OF THE REPUBLIC OF NAMIBIA

MINISTRY OF WORKS, TRANSPORT AND COMMUNICATION

DEPARTMENT OF TRANSPORT

NATIONAL TRANSPORTATION MASTER PLAN STUDY

VOLUME 3

TRAFFIC FORECAST

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Appendix 1 . Analysis of Traffic Counts

The efforts to do regressions of GDP and traffic, produced unsatisfactory results due to the shortage of reliable data. The traffic counts 1985 - 1995 from the permanent counting stations which were available are analysed in the following table. Also shown are the GDP figures for the corresponding years. Regression analysis for GDP in the primary, secondary and tertiary sectors with the development of light and heavy traffic did not yield sufficient explanatory power. It is believed that the time series are too short and in addition GDP figures are presently being re-evaluated. In addition the time series are disturbed by the 1989 - 1991 withdrawal of the RSA army.

TABLE A1.1: GDP AND GROWTH RATES FOR PERMANENT COUNTING STATIONS DATA (AADT)

example, data for the Keetmanshoop maintenance region, is presented in the next few tables.

Appendix 2 . Analysis of Cross-Border Data

The cross-border data analysed in the next section of this report were the only data that were available to provide insights into the distribution of traffic. The accuracy of this information with regards to it representing a 100 % sample is questionable. Queries regarding the sample size reveals that the project team did receive queries as to the accuracy of the information provided to the different countries. This must be kept in mind as no factor was available to expand data to reflect the actual traffic over the 40 day period.

Summary tables of cross-border movements are provided in the next two of tables.

Appendix 3 . Analysis of O/D Survey

The approach in this study was to make extensive use of available data to set up the base matrixes for traffic forecasting. Investigations into the availability and reliability of data opted the study team to motivate for additional origin-destination surveys at selected points to ensure that a reasonably reliable base year matrix can be developed to aid future forecasting efforts. The only data available on traffic distribution was the 1996 SADC cross-border data. The other source was the study conducted by a French study team which provided some indication of tonnage transported from mines, etc. This was not sufficient to support proper base year calibration for forecast purposes.

This survey was conducted at the start of the project to ensure that a reasonably accurate trip matrix can be developed. The survey points were:

1. ± 12 km south of Rehoboth on road no. TR1/4
2. ± 30 km north of Windhoek on road no. TR1/6
3. ± 6 km north-east of Swakopmund on road no. TR2/2
4. ± 7 km north-west of the centre of Tsumeb on road no. TR 1/10

The four survey points where data were collected are indicated in Figure A3.1. These surveys were executed over a three day period, on 3, 4 and 5 June 1997.

The data were coded to correspond to the cross-border survey data format and typed into Microsoft Excel spreadsheets. The data was edited and analysed manually to eliminate obvious errors. The raw data is available on floppy disk. The results of the survey at the four stations are described hereunder.

SURVEY RESULTS

The average percentage sampling rates at the four stations over the three day period are:

- Swakopmund – 69,7 %
- Rehoboth – 93,27 %
- Tsumeb – 93 %
- Windhoek – 73,7 %

The total vehicles counted versus the number surveyed are presented in Figure A3.2.

FIGURE A3.1 SURVEY STATIONS

FIGURE A3.2: OD SURVEY – VEHICLES COUNTED VERSUS SURVEYED

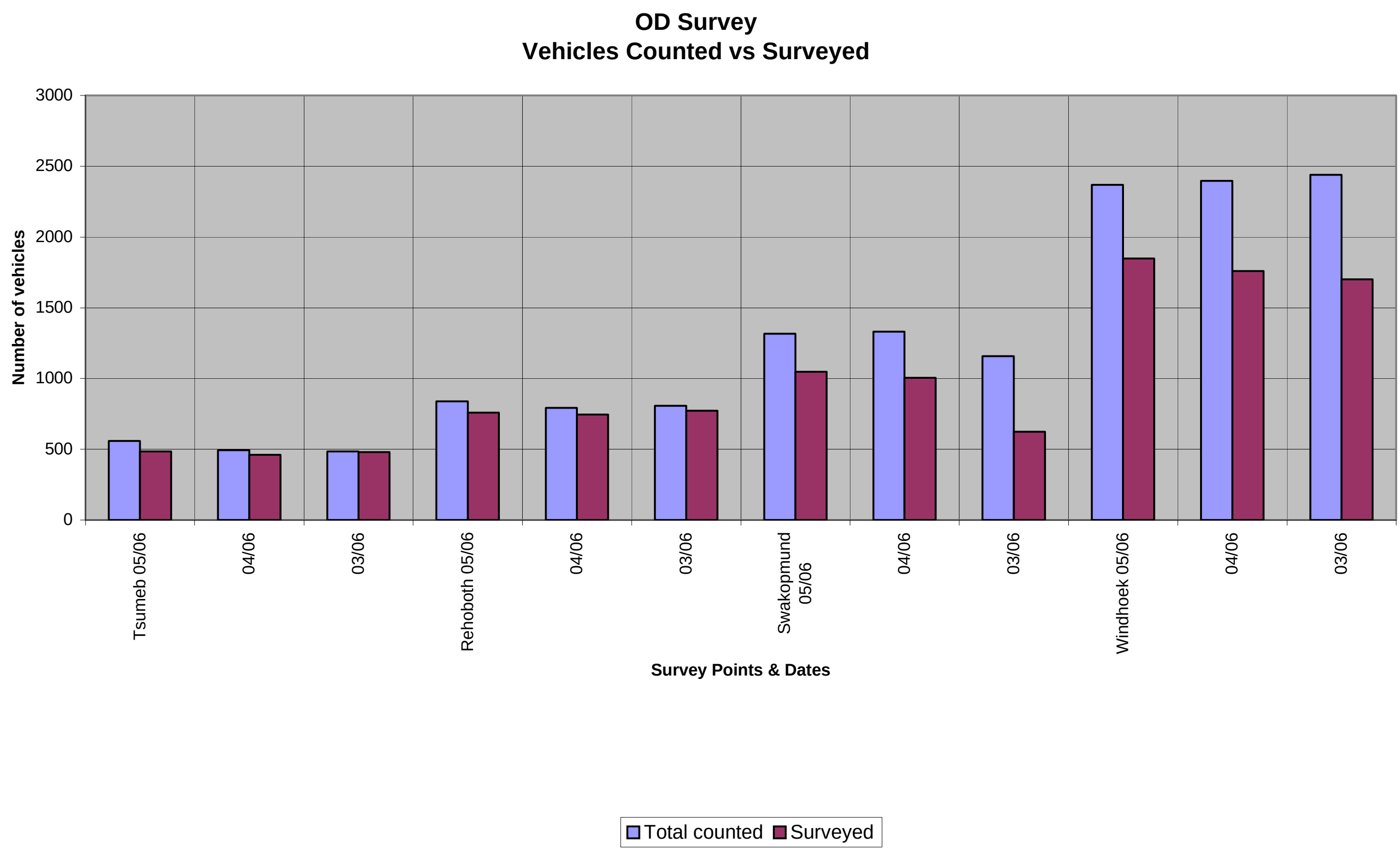


TABLE A3.1: MODE DISTRIBUTION AT THE FOUR COUNTING STATIONS (%)

Station	Light (%)	Bus (%)	Heavy (%)
Rehoboth	75,8	1,5	22,7
Windhoek	86,7	3,8	9,5
Swakopmund	85,6	3,6	10,7
Tsumeb	80	2,6	17,4

TABLE A.3.2: TRIP PURPOSE (%)

Station	Home (%)	Work (%)	Shop (%)	Education (%)	Holiday (%)	Other (%)
Rehoboth	23,2	37,4	4,7	1,6	17,9	15,2
Windhoek	23,7	48,69	7,7	0,6	11,6	7,8
Swakopmund	23,1	57,6	5,8	2	14,2	3,3
Tsumeb	15,1	61,2	6,1	-	16	1,6

TABLE A3.3: TRIP FREQUENCY (%)

	Daily (%)	Weekly (%)	Monthly (%)	Yearly (%)	Irregularly (%)
Swakopmund	26,7	33,9	18,4	8,3	12,6
Windhoek	21,3	31,8	26,9	7,0	13,9
Tsumeb	9,2	29,6	39,9	3,2	16,5
Rehoboth	2,1	21,6	11,2	3,2	31,8

The 11 most popular origins of vehicles passing through the survey points are indicated in Table A3.4.

TABLE A3.4: ORIGINS OF VEHICLES PASSING THROUGH THE SURVEY POINTS

Origins	Rehoboth (%)	Tsumeb (%)	Swakopmund (%)	Windhoek (%)
RSA	22,7	3,6	1,8	1,4
Karibib	-	-	1	1,3
Okahandja	2,3	1,0	0,6	23,4
Oshakati	0,8	21,3	-	1,4
Otjiwarongo	0,6	1,9	0,9	3,9
Swakopmund	0,7	-	47,4	3,3
Walvis Bay	3,1	1,2	12,5	2,8
Windhoek	36,1	18,9	12,1	55,5
Tsumeb	-	21,1	-	1,9
Omaruru	-	-	0,7	1,5
Ondangwa		9,1	-	0,5

The 11 most important destinations at all survey stations are indicated in Table A3.5:

TABLE A3.5: 11 MOST VISISTED DESTINATIONS OF VEHICLES PASSING THROUGH THE SURVEY POINTS

Destination	Rehoboth (%)	Tsumeb (%)	Swakopmund (%)	Windhoek (%)
Etosha Game Reserve	1,5	4,9	-	0,2
Grootfontein	0,5	4,4	-	1,3
Okohandja	1,1	0,8	-	22,1
Oshakati	1,5	21,9	1,5	3,1
Otjiwarongo	0,7	2,7	-	4,2
Rehoboth	10,6	-	-	0,4
Swakopmund	0,8	1	44,1	3,8
Walvis Bay	2,3	1,7	12,8	3,2
Tsumeb	-	19,4	-	2,1
RSA	17,7	0,7	1,5	1,6
Windhoek	33,5	19,3	13,7	51,2

TRIP MATRIXES

The survey data was used to create the final survey trip matrixes for the three modes. The raw survey data matrixes are presented in Tables A3.6-A3.8. Table A3.9 defines the zoning numbers which were allocated. The survey data was converted to AADT by using the following process:

- Calculate the average daily survey volumes (divide total survey data by three i.e. 3 day counts).
- Expand average daily survey traffic to actual average daily traffic by multiplying the survey data with the inverse of the sampling rate.
- Convert this average daily traffic to AADT by using expansion factors developed for the South African rural areas. A distinction was made in the application of these factors between areas which experience relatively high levels of commuter traffic like between Windhoek and Rehoboth and areas where no such commuting takes place.

The trip matrixes for light vehicles, heavy vehicles and buses were compiled using these expanded data. The heavy and bus matrixes, were combined and the light and heavy AADT matrixes used in the calibration process. Detail on the calibration process is discussed in more detail in Appendix 4.

TABLE A3.6: FINAL SURVEY DATA TRIP MATRIXES FOR LIGHT VEHICLES FOR THE BASE YEAR

TABLE A3.7: FINAL INTERNAL TRIP MATRIX FOR BUS

TABLE A3.8: FINAL INTERNAL TRIP MATRIX FOR HEAVY VEHICLES

TABLE A3.9: THE MAIN TOWNS SELECTED TO REPRESENT EACH ZONE

Zone number		Major Town
Internal Zones:	1	Oranjemund
	2	Noordoewer
	3	Karasburg
	4	Ariemsvlei
	5	Keetmanshoop
	6	Goageb
	7	Lüderitz
	8	Sossusvlei
	9	Maltahöhe
	10	Mariental
	11	Stampriet
	12	Gobabis
	13	Rehoboth
	14	Windhoek
	15	Namib-Naukluft
	16	Walvis Bay
	17	Swakopmund
	18	Omaruru
	19	Okahandja
	20	Henties Bay
	21	Otjiwarongo
	22	Outjo
	23	Otavi
	24	Grootfontein
	25	Tsumkwe
	26	Tsumeb
	27	Okaukeujo (Etosha)
	28	Opuwo
	29	Ruacana
	30	Oshakati
	31	Ondangwa
	32	Oshikango
	33	Otjivelo
	34	Rundu
	35	Katima Mulilo
	36	Ngoma
	37	Khorixas
	38	Möwe Bay
	39	Onseepkans

Appendix 4. Model Calibration

The bulk of the work to calibrate the Namibia major road model entails the collection, editing, analysing of base year information and selection of appropriate parameters to use as indicators for growth for the thirteen regions. The departure point was to use available data, in order to ensure that data collection efforts were limited to a minimum. The study team decided, after consultation with the Client, that O/D surveys (as discussed in Appendix 3) was an important data collection effort to enhance the base year information and ensure that the calibration process will be more effective.

The following assumptions and definitions were used as a basis for model development:

- **Light vehicles –** This includes all motor vehicles, both petrol and diesel driven, bakkies, LDV and double cab bakkies, 4X4's, minibuses and combi's

- **Heavy vehicles** – All goods vehicles including 2 axle light goods vehicle (less than 3.5 tons), 2-3 axle heavy goods vehicles (larger than 3.5 tons), 4-5 axle goods vehicle, 6 and more axle goods vehicle.

- **Buses –** All buses, both tourist and buses used for passenger transport. The matrix was developed separately but combined with the heavy vehicles matrix to allow comparison with available traffic counts.

- **Major road network** – The major road network model used as its base network all roads that are seen to be important links to the primary activity nodes in Namibia. It includes all trunk roads, selected main roads and district roads supplying access to areas identified as future development nodes. (Figure A4.1 indicates the zoning system for the major road network model.)

- **Zones** – The traffic zones for Namibia were based, where possible, on the regional and district boundaries. Where there is a big difference in terms of the primary influence spheres identified during a previous study, these boundaries were used. The traffic patterns will be closely related to the influence areas of the main traffic generators. A division was also done if any major development plans exits for a specific area and the future role may change significantly - an example of this is Möwe Bay. The border post were also, where required, separated into different traffic zones.

FIGURE 4A.1 : ZONES AND ROAD NETWORK

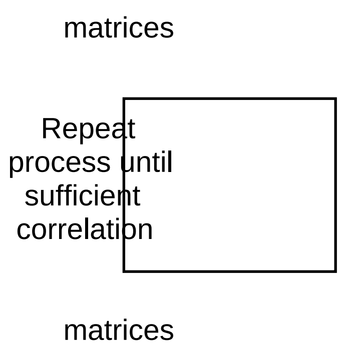
- **Estimated annual average daily traffic (EAADT)** – These values are determined by the DoT in a process whereby regional engineers and supervisors, estimate traffic volumes based on grader unit counts, other ad hoc traffic counts and general knowledge of the road network. These values were used to calculate the adjustment factors for model calibration. Figure 4A.2 shows the position of the screen lines on the major road network.

- **SADC** – Southern African Development Communities which consist of Angola, Botswana, Lesotho, Malawi, Mauritius, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe. The data from a cross-border survey for these countries formed the basis of the internal-external matrices.

- **EMME/2** – Graphical interface used for the calibration of the major road network model

The initial data analysis and aggregation of raw information into a survey based origin-destination matrix was done in Microsoft Excel. This process is discussed in detail in Appendix 3. The rest of the calibration process involved a lot of transfers and manipulations of the matrices which required a computer package. The computer package selected supplies user friendly data manipulation, management and display outputs which was essential to ensure proper base year calibration. The calibration process for the trunk road model was therefore executed in EMME/2. This software was selected as the appropriate user interface to be used at a later stage to upgrade to a more sophisticated computerised system for traffic forecasts.

The process to calibrate the base year model is summarised in the following diagram.



The base year matrixes were ”batched out” into Excel spreadsheet format to be used for the manual model.

The growth factors were, however, also applied in the computerised model to enhance the production of maps for the main report.

FINAL REPORT ON TRAFFIC FORECAST

TABLE OF CONTENTS

1 Background

1.1 Introduction

The Government of the Republic of Namibia (GRN), through its Ministry of Works, Transport and Communication (MWTC) has commissioned the Swedish Consultants KM International AB in association with VKE (Namibia) Inc., Nordic Consulting Group (NCG) and Swedish National Road Consulting AB (SweRoad) to undertake a National Transportation Master Plan Study (NTMPS). In order to cover all aspects of the Study, the Consultant has also sub-contracted the firms Opus International Consultants (NZ), AFRICON and SwedeRail.

The traffic forecast presented in this document should be seen in relation to the main objectives of the National Transportation Master Plan Study (NTMPS). The traffic forecasting methodology is necessary formedium and long term planning, as in the preparation of the master plan. The Terms of Reference for the the NTMPS require the Consultant to present a master plan for the period up to the year 2012. The forecast is an input to the master plan. The main focus in the preparation of this traffic forecast is on roads. In order to be useful for future road planning the traffic forecast is therefore presented for the years 1996 (calibration year), 2000, 2005 and 2012.

Namibia has, in comparison with other countries in the region, a well developed road network particularly in relation to its small population. Traffic flows are generally low. Thus the focus within the forecasting period will be on maintenance and improvements of the present road network rather than investments in completely new links. The main use of forecasts will therefore be as an input in a maintenance management system and for forecasting the need for pavement upgrading (*e.g.* gravel road to paved road). At the same time it is possible that one or two new road links may be introduced before the end of the forecasting period. Traffic forecasts will also be used for road user revenue projections.

Another important aspect in designing a forecasting tool is the present shortage of qualified staff at the Ministry of Works, Transport and Communication (MWTC). Consequently the forecasting technique should be geared towards implementation by consultants with minimum management input by the MWTC staff or (in future) the Roads Authority.

A simple approach to forecasting is to base it on historic trends. A more complex approach involves demand modelling based on traffic generation, distribution, modal split and traffic assignment to the network.

Following a discussion of the advantages and disadvantages of these different approaches it was concluded to use a more refined technique on the trunk road network and to use a historic trend analysis for the low volume network. The latter represent 80% of the road network but account for only 20% of total traffic. Although the trend model is difficult to implement now it will be straightforward once the new Traffic Surveillance System (TSS) is in place.

For the trunk road system which carries the remaining 80% of traffic volumes a simplified demand model has been used. This approach overcomes the shortage of reliable historical traffic data caused by a collapse of parts of the existing TSS.

At the same time this simplified approach mitigates some of the obvious shortcomings of a trend model, i.a.:

(i) a trend model does not provide for policy and intervention input

(ii) regression equations based on historical data may have low explanatory power

(iii) a trend model does not provide understanding of cause - effect relationships

The simplification is made possible due to the straightforward network with few alternative routes and concentrated activity centres. By a fairly limited Origin-Destination study combined with data from previous studies it was felt that a fairly accurate traffic distribution matrix could be constructed as a starting point for the forecast.

Input data for the forecasting must be limited to data which are readily available. In this respect, employment data were chosen as indicators of economic growth. Starting from 1996, employment figures will be annually updated by the Central Statistical Office (CSO). It will thus be possible to track the development of economic activity in the different regions. For the forecast presented here trends had to be derived from projections in the First National Development Plan.

The model also requires forecasts of future cross border traffic. For the forecast presented here, historic data were used in addition to speculations on future development of Walvis Bay, adherance to Government trade policies and guesses on the development in neighboring countries. In the future it should be possible to develop trend forecasts based on data from the road user charging system which includes the collection of fees at the international borders.

The forecasting model based on this simplified approach will have limitations. The model will be less suitable to handle certain policy questions such as:

(i) The effect of road user charges on traffic growth for different modes.

(ii)The effect of railway investments on road traffic growth

(iii)The effect of traffic patterns when gravel roads are being paved.

However, with the traffic surveillance system being developed it will provide the possibility to develop simple models to assist decisionmakers in adressing such questions.

It will also be possible at a later date to upgrade the model and refine it to include more zones and also other modes. When the new road management system is in place it will be more clear what is demanded of the forecasting model. At the same time there will be more data available which will make it possible to improve on the model. At that time it may also be feasible to consider integrating the model with the overall databases for road management.

The two methods used by the Consultant have been presented in a separate manual for traffic forecasting to be used by the Roads Authority and its consultants

1.2 Other Studies

Few other studies have attempted at predicting traffic growth in Namibia. The most recent effort, the National Transport Development Plan[1] (SOGREAH 1996) concludes that ”....*a traffic growth rate of between 3% and 4% per annum on the primary road network of Namibia appears appropriate and it corresponds to the average traffic growth rates of developing countries with a fairly low economic growth rate such as South Africa*.”

The DOT Economic Evaluation Manual[2] recommends that a traffic growth rate of 3.0% should be used as a national average.

In contrast, the First National Development Plan[3] (NDP1), the most recent policy paper, is planning for an economic growth rate of 5% peaking to 10% towards the second decade of the new millenium. This points towards higher traffic growth rates than assumed earlier. The actual development of the Namibian economy since the preparation of the NDP1 however points to traffic growth closer to the rate recommended in the DOT manual.

1.3 Level of Ambition

The planning horizon of the NTMPS is set out as the year 2012 in the Terms of Reference, thus requiring a forecast for that year. Since the proposed planning process also includes a medium term planning horizon, a year 2005 forecast has been prepared. The NDP1 is a five year plan ending in the year 2000. It was therefore deeemed necessary to develop forecast parameters also for that year.

The ambition of the NTMPS was to produce alternative scenarios, each one generating a separate forecast. In this report however, forecasts are only made for the Medium Growth Scenario. The forecasts were initially limited to the base road network which is the network as in 1997. However, as part of the formulation of the road master plan the effects on the traffic forecasts of a few new road links were tested.

The TSS traffic counts contain separate data on heavy and light vehicles. Ideally, a forecast for buses would have been appropriate. Data on buses were collected in the Origin-Destination survey and a bus transport matrix was elaborated based on these data. In the calibration process however, buses had to be combined with heavy vehicles to allow model values to be compared with field data. It is recommended that the new improved TSS investigates the possibility of including buses as one of the classified categories.

2 The Present Traffic Situation in Namibia

2.1 The National Transport Development Plan. Step 1.

The National Transport Development Plan. Step 1, (SOGREAH 1996) provides an excellent description of the Namibian transport system. That study is anticipated to be continued in August 1998 and is expected to adress issues such as traffic and trend forecasts.

Table 2.1.1 Transport mode of common commodities. Tons transported annually[a].

Commodity	RAIL	ROAD
CATTLE MEAT		17 000
CEMENT	210 000	90 000
CLINKER		60 000
COAL	99 000	
COKE		28 000
COPPER	30 000	
COPPER CONC	179 000	24 000
COTTON		6 000
DIESEL	1 000	
FISH		6 000
FISH MEAL		60 000
FLUORSPAR CONC	60 000	60 000
GRANITE		12 000
LEAD CONC	38 000	32 000
LEAD INGOTS	30 000	
MACKEREL FROZEN		15 000
MAIZE		45 000
MANGANESE ORE	120 000	120 000
MARBLE	15 000	16 000
PILCHARD CANNED		35 000
POL 1)	589 000	24 000
PYRITE	140 000	
SALT		200 000
SMALL STOCK MEAT		25 000
STEEL		14 000
SUGAR		24 000
SUNFLOWER OIL		3 000
WHEAT		35 000
WOOD		10 000
ZINC CONC	63 000	63 000
Total	1 574 000	1 024 000

1) POL = Petrol, oil and lubricants

[a]File goods1.mdb, table bas1, query commodity by mode

Based on data collected for the NTDP it is possible to get an understanding of goods movements in Namibia. In Table 2.1.1 above the annual tonnages of different commodities have been summarised based on data provided in the report. These data were mainly collected by interviewing transport suppliers and buyers. The listed commodities account for the majority of all long to medium haulage in Namibia. It is also illustrated in the table that railway is the large bulk carrier. Most railway tonnage will however also be transported by road to reach the final destination.

2.2 Present Traffic Surveillance System (TSS)

2.2.1 Traffic Counts

The Department of Transport (DOT) counts traffic on a regular basis on the proclaimed road network. All traffic counts are done by automatic counting machines connected to permanent inductive loops capable of separating between heavy and light vehicles. There are ten machines installed permanently while additional (less sophisticated) machines are used for one to two week counts alternating between 104 ad hoc stations. These ad hoc stations normally have permanently installed loops on the paved roads and temporary ones on the gravel roads.

In addition manual counts are carried out by the grader units in parallel with the blading operations. These counts are used by the maintenance organisation in preparing the plans for the grading units.

The Traffic Surveillance System[4] is presently being upgraded and will be based on a PC hardware and Progress software platform.

The TSS is designed to make use of mobile machine counters to perform non-classified coverage counts on all 2600 links on the road network during a four year cycle. This program has come to a stop because of a lack of suitable equipment. The existing TSS also lacks a module for calculating AADT from the database.

An obsolete TSS in combination with shortage of staff has resulted in a backlog of the analysis of traffic count data. Specifically, AADT is only available for the ten permanent stations. This fact was the main reason for opting to do traffic modelling rather than forecasts based only on historical growth trends.

2.2.2 Permanent Counting Stations

The permanent counting stations provide the most reliable information. Traffic growth for each of the stations was calculated as annual growth rates for 1985 - 1995 and 1990 - 1995.

As seen in Table 2.2.1 below, the average growth rate for the ten stations is between 5% and 6% annually. For heavy vehicles the growth rate has been more pronounced after 1990.

Table 2.2.1[a] Traffic growth at permanent stations.

	GDP in 1990 prices total and in sectors				Summary counting stations (AADT)			Employ-ment
Year	1990 N$mill	Primary	Secondary	Tertiary	Light	Heavy	Total	
1985	4541	1656	509	2376	3538	601	4139	
1986	4722	1770	505	2447	3707	597	4304	
1987	4927	1859	534	2534	4067	653	4720	
1988	4988	1830	565	2593	4486	725	5211	
1989	5071	1815	577	2679	4837	717	5554	
1990	5081	1699	618	2764	4450	597	5047	
1991	5498	1949	554	2995	4495	645	5140	357 000
1992	5954	2079	695	3180	4635	703	5338	369 000
1993	5819	1853	693	3273	4815	715	5530	385 000
1994	6215	2073	768	3374	5402	789	6191	392 000
1995	6430	2158	786	3486	5528	845	6373	404 000
´1985-1995	42%	30%	54%	47%	56%	41%	54%	
Annually	4.2%				5.6%	4.1%	5.4%	
1991-1995	17%	11%	42%	16%	23%	31%	24%	13%
Annually	4.3%				5.8%	7.8%	6%	3.3%
multiplier employment 1991-1995					1.7	2.4	1.8	
multiplier GDP 1991-1995					1.4	1.8	1.4	
multiplier GDP 1985-1995					1.4	1.0	1.3	

2.2.3 Ad hoc traffic counting stations

Data from the 104 ad hoc stations, in all about 150 records, have also been analysed. Annual traffic growth was determined for all stations which were counted more than once between 1989 and 1997. As these are raw data and no corrections made for seasonal or local circumstances only the mean growth rate for different types of roads were calculated. The results are presented in table 2.2.2 below.

[a]File vehicles.xls, sheet Summary

Table 2.2.2[a] Annual traffic growth based on Ad Hoc counts.

Pavement Type	Road Class	Growth
Paved	TRUNK	16%
Paved	MAIN	3%
Gravel	MAIN	-7%
Gravel	DISTRICT	16%

The results must be interpreted with caution. In general it is more difficult to obtain statistically significant growth figures on the low-volume road network. It is also important that the ad hoc counts are carried out so that seasonal and local variations are not allowed to unduly influence the results.

Lately, Estimated Average Annual Daily Traffic (EADT) has been determined by DOT[b] for all the road links in the country. The process repeats a 1991 exercise whereby regional engineers and supervisors estimate traffic volumes based on grader unit counts, other ad hoc traffic counts and general knowledge of the road network and traffic.

3 Traffic Forecast for 2005 and 2012

3.1 Regional Economy

In Table 3.1.1 below, employment data from the 1991 Census[5] are shown. The regional differences are clearly indicated and there are also large discrepancies in income between the regions. In general the regions in the north have the lowest income per household. Not surprisingly, these are farming communities which generate little surplus. In contrast, Khomas has a more diversified industry and subsequently the highest household incomes are found in this region.

[a] File total_ve.xls, sheet Summary
[b] File TSS97.zip

Table 3.1.1[a] Regional employment (* 1000 persons) and average income (N$ per household and year).

Region		Caprivi	Erongo	Hardap	Karas	Khomas	Kunene	Ohang wena	Oka- vango	Oma- heke	Omu- sati	Oshana	Oshi- koto	Otjozun djupa
Agriculture, hunting, forestry	A	17,80	3,44	5,88	4,28	3,85	13,31	27,06	23,79	8,40	36,75	12,28	17,93	12,35
Fishing	B	0,99	0,10	0,00	0,93	0,03	0,00	0,17	0,02	0,00	0,32	0,15	0,09	0,01
Mining and quarrying	C	0,03	2,49	0,05	6,05	0,96	0,09	0,46	0,31	0,01	0,58	0,43	2,34	0,89
Manufacturing	D	0,77	1,22	0,56	0,69	5,08	0,34	3,32	0,68	0,26	2,91	2,31	1,79	2,98
Electricity, gas, water	E	0,10	0,18	0,18	0,15	0,85	0,22	0,12	0,13	0,19	0,15	0,18	0,07	0,45
Construction	F	0,72	1,78	2,13	1,01	5,40	0,82	0,65	0,64	0,53	1,11	1,77	0,56	1,53
Wholesale and retail trade,veh.rep	G	1,08	1,99	1,41	1,56	10,04	0,91	2,11	1,34	0,85	3,13	4,90	1,98	2,49
Hotels and Restaurant	H	0,14	0,52	0,20	0,39	1,15	0,51	0,07	0,06	0,08	0,03	0,19	0,25	0,45
Transport , storage, communication	I	0,14	0,48	0,49	0,96	4,26	0,19	0,14	0,13	0,27	0,17	0,49	0,36	1,25
Financial Intermediation	J	0,12	0,22	0,18	0,22	2,32	0,06	0,01	0,18	0,08	0,01	0,18	0,10	0,26
Real estate, renting, business activities	K	0,11	0,26	0,13	0,11	3,05	0,07	0,03	0,15	0,09	0,06	0,17	0,10	0,30
Public adm., defence, soc. security	L	1,59	1,05	1,05	1,59	8,93	1,17	0,67	1,65	0,77	0,69	2,64	0,62	4,73
Education	M	1,52	1,15	1,53	1,25	3,61	1,34	1,66	1,50	1,08	2,60	1,92	1,47	1,77
Health and social work	N	0,43	0,55	0,47	0,70	3,25	0,40	0,47	0,81	0,21	0,82	1,39	0,61	0,65
Other community, soc. & personal service	O	0,22	0,48	0,29	0,39	2,52	0,16	0,21	0,27	0,14	0,23	0,30	0,26	0,37
Private households with employed persons	P	1,02	1,79	1,94	1,71	6,63	0,89	0,28	0,63	1,64	0,51	0,82	1,18	2,81
Extra-territorial organizations & bodies	Q	0,01	0,02	0,00	0,00	0,56	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Not stated	R	0,05	0,09	0,06	0,05	0,24	0,03	0,07	0,06	0,02	0,10	0,08	0,09	0,07
Income/household, N$		7248	21055	22308	26991	47409	10583	6439	8944	17183	8441	10528	8689	13756

[a]File employ1.xls, sheet 1991 Census

3.2 Development Indicators

3.2.1 GDP, Employment and Road Traffic

The Central Statistical Office has recently revised its GDP estimates in the Secondary sector.

In order to illustrate the development trends a comparison has been made with GDP, employment and traffic growth rates. GDP figures are broken down into the Primary, Secondary and Tertiary sectors. The share of the Primary sector which includes mining and agriculture is declining while the other sectors are gaining. Still, the Secondary sector which includes manufacturing only accounts for about one eighth of the economy. It is however the fastest growing sector and is typically a transport generating sector. The growth in the Secondary sector has been particularly pronounced after 1990.

Long term traffic growth has been compared to the growth in GDP and employment. Multipliers were then established by dividing the growth rate of traffic with the growth rates of GDP and employment.

The multiplier for heavy and light traffic combined is about 1.4 for GDP and about 1.8 for employment. The difference in values is explained by increases in productivity whereby employment grows slower than GDP. For heavy traffic the picture is confused by the conditions immediately before and after independence. Between 1989 and 1990 there was a sharp decline in goods traffic as measured by the permanent counting stations. The handover of Walvis Bay to Namibia has also effected goods transport. Since 1992 heavy traffic on the Trunk Road east of Swakopmund has grown with about 40%.

3.2.2 Other Indicators

Historic traffic growth has also been checked against other indicators. Historic fuel consumption has been calculated by the Road User Charges Study[6] based on fuel sales figures and correlated against estimated fuel consumption by different vehicle categories. The same study also made use of data collected for the years 1990 and 1992 to estimate the growth of the automobile fleet. The growth figures were based on vehicle registration data for the Windhoek area only. The new Namibian Traffic Information System (NATIS) for *inter alia* vehicle registration, which is being implemented, will in futureprovide regular and consistent data on the growth of the vehicle fleet.

Data on vehicle sales through the Namibia Motor Industry Federation (NAAMSA) provide monthly compilation of new vehicle sales. Data are not available prior to 1996.

These cross checks confirm the general picture of a rapid traffic growth outpacing the growth of GDP. See Table 3.2.1 below.

Table[a] 3.2.1 Indicators on traffic growth.

Indicators on Traffic Growth		
Vehicle Numbers and growth	Numbers	Growth
Heavy vehicles (000) 1992	12,8	5,5%
Light vehicles (000) 1992	153,0	5,5%
Fuel Consumption and growth	Consumption.	Growth
Heavy vehicles (000 tons) 1992	176	12%
Light vehicles (000 tons) 1992	270	7%
Vehicle sales growth 1996-1997	Sales 1996	Growth
Heavy vehicles (NAAMSA)	159	14%
Light vehicles (NAAMSA)	6831	8%

3.2.3 Cross Border Traffic

A cross border survey[7] was conducted in 1996. As seen from the Table 3.2.2 below, the goods movement between Namibia and the Republic of South Africa (RSA) accounts for 76% of the total tonnage crossing the Namibian border by road. The corresponding figure for Angola is 7%.

Transit transport from and to RSA account for about 5% of the goods movement and includes primarily overseas export/import through Walvis Bay.

The cross-border traffic between RSA and Namibia is monitored jointly by the Departments of Transport in the two countries. The 1994/95 survey[8] estimates the total road transport between the two countries at 815 thousand tons per year, up about 25% from a survey made the year before. Consultants estimates[9] in 1988 arrived at a corresponding figure of about 200 thousand tons excluding 200 thousand tons of salt export through Walvis Bay which at that time was part of South Africa. These figures indicate a rapid growth of goods traffic by road.

[a] File employ1.xls, sheet Summary

Table 3.2.2[a] Cross-Border traffic 1996. Percentage of total tonnage.

Namibia Cross Border Survey 1996, tons distribution													
Country/	Destination												
Origin	Ang	Bots	Mal	Moz	Nam	RSA	Swa	Tan	Zam	Zim	Oth	Unk	Total
Angola	0,8%				1,5%						0,0%		2,4%
Botswana					1,0%								1,0%
Malawi													0,0%
Mozambique	0,0%												0,0%
Namibia	5,0%	1,3%		0,0%	0,1%	31,6%	0,1%	0,0%	2,7%	2,4%		0,0%	43,1%
RSA	0,4%				44,3%	0,0%				0,0%	3,4%	0,0%	48,1%
Swaziland													0,0%
Zambia		0,0%	0,0%		0,8%	0,0%				0,0%			0,8%
Zimbabwe		0,0%			3,5%	0,0%				0,0%			3,5%
Other	0,0%	0,0%			0,2%	0,7%				0,0%			0,9%
Unknown					0,0%							0,2%	0,2%
TOTAL	6,3%	1,3%	0,0%	0,0%	51,4%	32,3%	0,1%	0,0%	2,7%	2,4%	3,4%	0,2%	100,0%

Note: “Other” primarily represents export/import through Walvis Bay.

The Cross Border Study from 1994/95 concludes that average load for trucks into Namibia is about 20 tons and from Namibia into RSA the average load is 14 tons. The number of trucks is about equal in both directions as trucks will normally return to their home base regardless if they have full return loads or not.

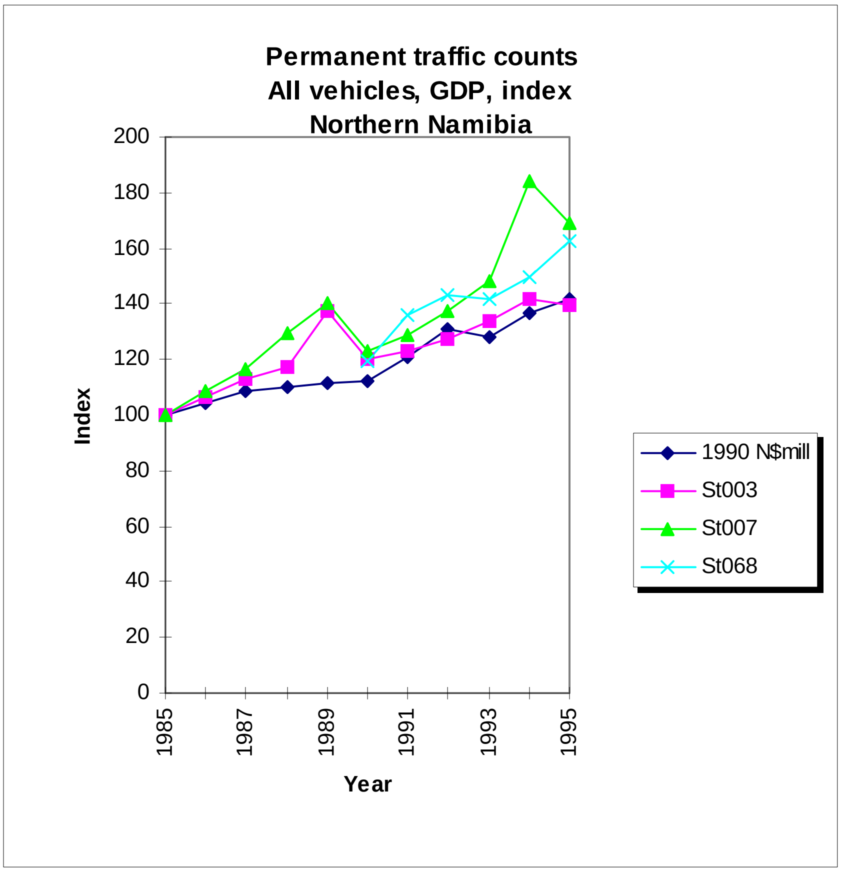
3.2.4 Major Factors Influencing Traffic Growth

3.2.4.1 General

Traffic growth normally does not follow a smooth curve. In Figure 3.2.1 below are shown the results from traffic counts at three permanent stations in Northern Namibia. Traffic growth follows or is higher than the economic development measured as GDP growth. The process of independence disturbed the traffic growth pattern and there was a sharp drop in traffic from 1989 to 1990 related to the withdrawal of the South African army.

[a] File trade.xls, sheet distribution

Figure 3.2.1[a]. Diagram showing traffic growth in relation to GDP growth.



Note: St003 is located on TR1/9 south of Tsumeb
St007 located on TR2/5 south of Outjo
St068 is located on TR1/7 between Okahandja and Otjiwarongo

Dramatic changes such as the transition to independence will not occur frequently. It points out however the difficulty in making predictions. Other major factors which are likely to influence traffic growth are discussed below.

3.2.4.2 Economic Development

Economic growth contributes to traffic growth in a number of ways. First, the growth of business requires additional transport. Secondly, private incomes increase, allowing households to buy and use automobiles. Finally, economic development results in specialisation where comparative regional advantages are maximised, which results in increased trade internally and externally.

[a]File vehicles.xls, sheet summary diagram

It is assumed that traffic growth will be faster than economic growth. Historically this is proven in Namibia as well as in other growing economies with a comparatively low car ownership. As an indicator for economic growth we have chosen employment rather than GDP. This avoids the problem of GDP fluctuations which result merely from price changes in the commodity markets.

Another practical aspect is that employment figures are closely monitored and from 1996 onwards, data on employment will be made available annually by the Central Statistical Office. The break down will be on a regional basis by economic activity. Unfortunately data further back than 1991 are considered less reliable. Employment figures are therefore only available starting with the 1991 Census.

In contrast, GDP figures are based on a survey of a limited number of companies. It is therefore not reliable to disaggregate the data as required by the traffic forecasting model.

3.2.4.3 Transport Regulation

The White Paper on Transport Policy recommends that the regulation framework encourages the most effective use of the competing modes. The Namibian Railway operated by TNL has de facto operated in a deregulated environment since 1991/1992 and the effect has probably been a faster increase for road traffic than for railway traffic. Theoretical studies[10] (Van Wyk and Louw, TRR 1154) indicate that deregulation has a rather marginal effect on modal split and it is not likely that the effect has been more than 3-4%. The proposed road user charges system and a more rigorous control of overloaded vehicles will probably balance the development of costs which generally has been faster for the railways than for the road transport industry[a] (SOGREAH/SYSTRA 1996).

[a] SOGREAH 1996, chapter 7

3.2.4.4 Cross Border Issues

The completion of the Trans Kalahari Highway has shortened the distance between the Gauteng Region in RSA and Namibia substantially. The feasibility study for the Trans Kalahari estimated that an additional 30 to 40 trucks per day will be generated[a]. This is to be compared to only 6 vehicles per day recorded during the 1996 survey (220 vehicles in 40 days) at the Buitepos border point of which less than one per day was transit through Botswana (see Table 3.2.3 below).

Table 3.2.3[b] Buitepos border crossing. Number of vehicles during a 40 days survey period.

Origin Country	BO	NA	SO	UN	ZI
Botswana		110			
Namibia	97		8		2
RSA		3			
Unknown				3	

With the Trans Kalahari it is likely that some of the 37 vehicles per day on the Gauteng-Namibia route will divert to the Trans-Kalahari (see Table 3.2.4 below). The percentage will depend on Botswana cross border procedures and road user charges. The distance from Gauteng to Windhoek/Walvis Bay is about 400 km shorter using the new Kalahari route. Using a simple assignment formula[c] it is estimated that about 20 vehicles will use the shorter route. An ad-hoc count some 100 km East of Gobabis during the period 7-19 April 1998 (about one month after the official opening of the Trans-Kalahari Highway) indicated a total traffic per day of about 180, of which 10 were heavy.

Durban is the major container port in the region with a through-put of 900 000 TEU in 1995/96. If 2% of these containers instead are shipped through Walvis Bay, as suggested by TNL, it will result in an additional 50 TEUs per day on the Trans Kalahari Highway. These increases would close to double the throughput of containers in Walvis Bay but be in line with NamPort's development plans.

[a]Quoted in ref 12
[b]File c-b96.mdb, table c-b96, query Origin/Destination Vehicles Buitepos
[c]p1=c2/(c1+c2)*100, where P1= percentage of alternative 1, ci =costs of alternative i

Table 3.2.4[a] Border to RSA crossings. Number of heavy vehicles per day.

To/From South African Provinces	Heavy vehicles per day
Northern Province/Petersburg	4
Gauteng/Pretoria/Johannesburg	37
North West/Mmbatho/Rustenburg	19
Mpumulanga/Nelspruit/White River	4
Free State/Blomfontein/Welkom	2
Kwazulu-Natal/Durban/Richardsbay	2
Easter cape/Port Elizabeth/East London	2
Northern Cape/Kimberley/Upington/Springbok	8
Western Cape/Cape Town/Worcester/George	19
Total	96

While the development of traffic to and from RSA depends on investments in infrastructure, transport across the Angola border will depend largely on the political development in this neighbouring country. In contrast to Botswana, Angola represents a big market with a population of about 12 million people. At present the cross border traffic is limited but is likely to grow quickly provided that the security situation is improved and consumer demand is boosted through economic growth. The table below show that the border trade is significant and larger than at the Botswana border. However, it is likely to be smaller consignments to satisfy the local markets on both sides of the border with limited implications on the trunk road network. Data also indicate that the survey method may be flawed, otherwise it is difficult to explain the large difference in the number of vehicles going into Angola compared to the number going out (See Table 3.2.5 below).

Table 3.2.5[b] Cross border traffic at Oshikango. Number of heavy trucks during a 40 days survey period.

Origin Country	AN	BO	NA	OT	SO	UN
Angola	15		195	2		
Mozambique	1					
Namibia	371	1	3		1	
Other	1					
RSA	4					
Unknown						18

[a]File c-b96.mdb, table c-b96, query Origin/Destination Vehicles RSA
[b]c-b96.mdb, table c-b96, query Origin/Destination Vehicles Oshikango

3.2.4.5 Network Investments

As discussed above network investments tend to change travel patterns as the road users strive to minimise their transport costs.

Feasibility studies made for road improvement projects in Namibia have estimated the effect paving of a gravel road will have on traffic volumes. Additional traffic of 50-100 vehicles per day was assumed in the Gobabis to Aranos Link Road feasibility study[11]. These conclusions were based on a socio-economic survey of the population along the road and the estimate thus represent generated traffic. On the Oranjemund Link Road the estimate[12] was an additional 50 vehicles per day as diverted traffic calculated from Origin-Destination Survey data. Post-construction surveys could be an important tool in establishing likely parameters to be used in the planning process.

New links are proposed in the NDP1 and the traffic forecasting model will be used to investigate the effect of these proposed links as part of the master plan for developing the road network.

3.3 Scenarios

A traffic forecasting model relies on accurate input parameters. It could be argued that forecasting the input parameters is no easier task than estimating the traffic growth directly. However, the advantage of using a forecasting model is that it is possible to study the effect on varying input parameters as part of a sensitivity analysis. The model can then be used to test the effect of various policy options on the traffic volumes on the road network. It is also important to integrate the forecast with the macro-economic framework established in the Namibia Development Planning process.

It is easily understood that because of the complexity of the models it is impractical to try to investigate all possible combinations of input variables. Instead it is useful to talk in terms of scenarios where each scenario represents a likely combination of polices and outcomes.

The scenarios presented below are based on the three scenarios which are included in the NDP1. These scenarios are not policy oriented but rather reflect that Namibia is dependent on economic factors which it can hardly control. Among these are world market prices on mining products and climatic factors which effect the cattle and fishing industry.

3.3.1 High-growth Scenario

In this scenario, *"...weather conditions and fish stocks are good and world markets for Namibian goods and services buoyant. This stimulates dynamic private sector growth and allows modest growth in Government services."* The offshore mining for diamonds is successful spurred by growing world market demands and limited supply due to political instability in competing countries. Global financial markets are stable resulting in a construction boom stimulating export of Namibian cut stones. Export Processing Zones are successfully established in Walvis Bay and at the Angolan border where light manufacturing develops.A substantial service industry related to the fishing and the diamond explorations is also growing up with Luderitz as centre. The fishing stock is stable and increasing domestic demands promotes added value for the retail and transport industries. The improved highways to neighbouring landlocked countries are used to promote export of fish products processed in Namibia.

Imports from RSA are substituted for more domestic production and overseas imports through Walvis Bay. Development of the secondary and tertiary sectors in the urban areas result in fast growing cities and less reliance on subsistence farming.

The tourism industry is flourishing. The expansion is primarily among tourists from overseas and from other neighbouring countries than RSA. Tourism is also benefiting from political stability in Angola.

Foreign investments are primarily in the mining and in the tourism sector but also in the manufacturing sector spurred by successful ventures in the EPZ.

3.3.2 Medium-growth Scenario

In this scenario, *"...weather, fish stocks and world market conditions are less favourable. This stimulates high private sector growth and allows restrained growth in Government services."*

The offshore mining for diamonds is increasing with moderate growth. Growth industries are manufacturing and the tourism industry. Towards the end of the forecasting period the employment in the Secondary Sector is one fourth of total employment compared to about a tenth in the base year 1996. Employment in the Tertiary Sector is minimal but there is a very significant shift from Government employment towards private employment in the Tertiary Sector. Government Employment is expected to grow significantly less than population growth as public services are increasingly performed by the private sector.

Imports from RSA are substituted for more domestic production and overseas imports through Walvis Bay. The Cement Factory extension in Otjiwarongo is fully operational in the year 2000 with an annual production of altogether 250 000 tons. Development of the secondary and tertiary sectors in the urban areas result in expanding cities and less reliance on subsistence farming.

The tourism industry benefits from strong growth in OECD countries.

Foreign investments are primarily in the mining and in the tourism sector but also in the manufacturing sector spurred by successful ventures in the EPZ.

3.3.3 Low Growth Scenario.

In the low-growth scenario *"...weather, fish stocks and world market conditions are less favourable. Private sector growth remains low and Government continues to dominate a stagnant economy"*. RSA remains a dominant trading partner and employment still relies on the informal and primary sector.

3.3.4 Summary of Growth Scenarios.

In the table below, basic assumptions have been summarised for the three scenarios. Population and GDP growth are taken from the long term forecasts in the NDP1. In the Low Growth scenario the Low Population Growth rate has been assumed and employment growth is commensurate with the population growth. GDP growth is faster than employment growth due to increased productivity in non-primary sectors. Trade remains high as a proportion of GDP.

In the Medium Growth Scenario, the Medium Population Growth is assumed and employment forecasts are based on assumed growth in each economic sector. The GDP figure is taken from the NDP1 forecast and converted to 1996 N$. Trade in proportion of GDP is expected to decline to become more in line with other economies in Southern Africa. Still trade is higher than in the low growth scenario.

The High Growth Scenario uses the high population growth figures from the NDP1. It is estimated that employment and productivity is higher than in the Medium Growth. The increase in employment 1996 to 2012, 430 000 shall be compared to a projected increase in the economically active labour force 15-65 years of about 500 000 during the same period.

The difference between the Medium and High Growth Scenario is not large. The more optimistic growth scenario implies that GDP targets are reached a few years earlier than in the Medium Growth Scenario. The scenarios are summarised in Table 3.3.1 below.

Table 3.3.1[a] Summary of scenarios.

	All Scenarios	Low Growth	Medium Growth	High Growth
	Base 1996	Forecast 2012	Forecast 2012	Forecast 2012
Population (000)	1 650 000	2 600 000	2 650 000	2 700 000
Employment (000)	424 000	700 000	854 000	900 000
GDP N$ Million (1996 Prices)	13 886	25 000	35 000	40 000
Exports N$ Million(1996 Prices)	6 840	12 000	14 000	15 000
Imports N$ Million(1996 Prices)	8 032	13 000	16 000	20 000
RSA Trade (Percent of total trade)	80%	75%	70%	65%
GDP/Employed	32 750	35 714	40 984	44 444
Trade/GDP	107%	100%	86%	88%
Employment/Population	26%	27%	32%	33%

3.3.5 Risks.

The Medium growth scenario has been used for the traffic forecast. However, the assumptions are subject to risks which are difficult to assess. Among these are drought and diseases which will effect the cattle industry, shifts in global ocean currents influencing the marine environment, fluctuations in commodity markets, political stability in the region etc. The assumptions should therefore be monitored and the forecast adjusted accordingly.

The projected rise in employment is dependent on an expansion of the private sector which is influenced by Government policy on industry, labour, education, immigration, urbanisation and housing.

The growth in GDP is obtained primarily by shifting from low-productivity activities to high productivity. For example GDP per employee is presently about N$ 50 000 - N$ 100 000 in growth industries compared to for example N$3000 in agriculture.

[a]File gdp, sheet Summary

Changes in trade are made on the assumption that trading patterns will become more in line with other countries in the region. GDP growth will then need to be faster than growth of trade which will require growing domestic demand of Namibian products. Domestic demand is highly dependent on Government fiscal and monetary policies.

3.3.6 Forecast Scenario

3.3.6.1 Internal traffic

Employment figures have been obtained from the 1991 Census with estimates up to year 2000 provided by the NDP1. The Census figures were used to obtain an employment pattern in each one of the thirteen regions, see Table 3.1.1. These figures were slightly revised to correspond to differences in the definitions of economic activity between the Central Statistics Office and the NDP1. The economic growth forecast for each economic activity is shown in Table 3.3.2 below. In this table the forecast to year 2000 is based on the NDP1. Beyond that, the description of the medium growth scenario is translated into growth figures for the different economic sectors. It has also been assumed that there is a limited growth potential in the primary sectors and secondary sectors directly related to the primary sectors (food processing).

The forecasts were applied to each region in such a way that employment in each economic sector was distributed among the regions in proportion to their share in the base year. The effect is that regions with a large percentage of growth industries will develop faster than other regions.This is shown in Table 3.3.3 below.

Table 3.3.2[a] Projected employment growth of economic sectors.

Projected annual employment growth									
Employment (000) and		Base 1996		Forecast 2000		Forecast 2005		Forecast 2012	
annual growth in preceding period								Medium	
Region/Industry		Empl.	Growth	Empl.	Growth	Empl.	Growth	Empl.	Growth
Agricultural (Comm.)		42,00		47,00	2,9%	51,70	1,9%	52,25	0,2%
Agricultural (Subsistence)		159,00		179,00	3,0%	196,90	1,9%	216,59	1,4%
Fishing		9,00		13,00	9,6%	13,00	0,0%	13,00	0,0%
Diamond mining		5,00		3,00	-12,0%	3,45	2,8%	3,97	2,0%
Other mining		7,00		9,00	6,5%	11,70	5,4%	15,21	3,8%
Manufacturing		11,00		17,60	12,5%	35,20	14,9%	88,00	14,0%
Fish Processing		4,00		8,00	18,9%	12,00	8,4%	20,40	7,9%
Meat Processing		4,00		6,40	12,5%	9,60	8,4%	16,32	7,9%
Electricity and water		2,00		2,00	0,0%	2,60	5,4%	3,64	4,9%
Construction		26,00		35,00	7,7%	52,50	8,4%	89,25	7,9%
Trade		41,00		55,00	7,6%	82,50	8,4%	140,25	7,9%
Hotels and Restaurants		4,00		5,37	7,6%	9,66	12,5%	24,15	14,0%
Transport and comm.		12,00		14,00	3,9%	21,00	8,4%	35,70	7,9%
Finance and business services.		10,00		12,00	4,7%	15,60	5,4%	26,52	7,9%
Social and personal services		10,00		12,00	4,7%	15,60	5,4%	21,84	4,9%
General government		75,00		76,00	0,3%	79,80	1,0%	83,79	0,7%
Other producers		3,00		3,00	0,0%	3,15	1,0%	3,31	0,7%

The regional growth scenario has been discussed with the Ministry of Local Government and Housing. Two factors may need additional attention. The development in the northern regions may be faster due to its closeness to the Angola market. In these regions there is a comparative advantage which is not accurately reflected in the historical data. Another concern is the growth constraints of Windhoek which relate to a shortage of land and water for further development.

[a]File employ1.xls, sheet Summary

The growth of employment in the different regions was translated into growth of traffic generation in the different regions according to Table 3.3.4 below. Multipliers from the study of historical data were used. It is expected that these multipliers will decrease with time.

In future the forecasting model will be fine tuned by adjusting the growth multipliers. This will be done by monitoring the employment and traffic growth.

Table 3.3.3[a] Forecast of employment in Regions

Forecast of employment in Regions														
Employment (000)														
Region	Caprivi	Erongo	Hardap	Karas	Khomas	Kunene	Ohang-wena	Ka-vango	Oma-heke	Omu-sati	Oshana	Oshi-koto	Otjozun djupa	SUM
Total employment year 2000	33,36	30,89	20,35	24,05	79,82	24,96	48,18	39,98	16,92	63,65	39,78	35,78	39,65	497,37
Employment 1996	28,92	23,75	17,27	22,70	66,45	21,88	40,67	35,12	14,83	54,57	33,30	30,60	33,94	424,00
Annual growth	3,6%	6,8%	4,2%	1,5%	4,7%	3,3%	4,3%	3,3%	3,4%	3,9%	4,5%	4,0%	4,0%	4,1%
Total employment year 2005	38,62	38,34	25,90	30,04	108,66	29,51	58,14	46,13	20,01	75,71	50,86	43,61	50,43	615,96
Employment 2000	33,36	30,89	20,35	24,05	79,82	24,96	48,18	39,98	16,92	63,65	39,78	35,78	39,65	497,37
Annual growth	3,0%	4,4%	4,9%	4,5%	6,4%	3,4%	3,8%	2,9%	3,4%	3,5%	5,0%	4,0%	4,9%	4,4%
Total employment year 2012	47,41	53,64	36,99	42,07	174,65	37,71	76,91	55,73	25,33	97,48	73,63	58,56	74,08	854,18
Employment 2005	38,62	38,34	25,90	30,04	108,66	29,51	58,14	46,13	20,01	75,71	50,86	43,61	50,43	615,96
Annual growth	3,0%	4,9%	5,2%	4,9%	7,0%	3,6%	4,1%	2,7%	3,4%	3,7%	5,4%	4,3%	5,6%	4,8%

Source Household Census 1991 Table E06

[a]File employ1.xls, sheet Summary regions

Table 3.3.4[a]. Annual employment and traffic generation growth.

Annual employment and traffic growth															
Time period	Multi-plier	Caprivi	Erongo	Hardap	Karas	Khomas	Kunene	Ohang-wena	Oka-vango	Oma-heke	Omu-sati	Oshana	Oshi-koto	Otjozon djupa	SUM
1991 - 1996 annual growth															
Annual employment		4%	3%	3%	3%	3%	4%	4%	4%	3%	4%	4%	3%	3%	3%
Heavy vehicles traffic generation	2,4	9,0%	7,5%	7,4%	6,8%	8,1%	8,5%	9,3%	9,3%	6,0%	9,4%	10,1%	6,6%	6,2%	8,2%
Light vehicles traffic generation	1,7	6,7%	5,6%	5,5%	5,0%	6,0%	6,3%	6,9%	6,9%	4,5%	7,0%	7,5%	4,9%	4,6%	6,1%
1996 - 2000 annual growth															
Annual employment		3,6%	6,8%	4,2%	1,5%	4,7%	3,3%	4,3%	3,3%	3,4%	3,9%	4,5%	4,0%	4,0%	4,1%
Heavy vehicles traffic generation	2,2	8,0%	14,9%	9,2%	3,2%	10,3%	7,4%	9,5%	7,3%	7,4%	8,6%	10,0%	8,8%	8,7%	9,0%
Light vehicles traffic generation	1,6	5,8%	10,9%	6,7%	2,3%	7,5%	5,4%	6,9%	5,3%	5,4%	6,3%	7,3%	6,4%	6,3%	6,5%
2000 - 2005 annual growth															
Annual employment		3,0%	4,4%	4,9%	4,5%	6,4%	3,4%	3,8%	2,9%	3,4%	3,5%	5,0%	4,0%	4,9%	4,4%
Heavy vehicles traffic generation	2,1	7,6%	14,3%	8,8%	3,1%	9,9%	7,0%	9,1%	6,9%	7,0%	8,2%	9,5%	8,4%	8,3%	8,5%
Light vehicles traffic generation	1,5	5,4%	10,2%	6,3%	2,2%	7,0%	5,0%	6,5%	4,9%	5,0%	5,9%	6,8%	6,0%	5,9%	6,1%
2005 - 2012 annual growth															
Annual employment		3,0%	4,9%	5,2%	4,9%	7,0%	3,6%	4,1%	2,7%	3,4%	3,7%	5,4%	4,3%	5,6%	4,8%
Heavy vehicles traffic generation	2,0	7,3%	13,6%	8,4%	2,9%	9,4%	6,7%	8,6%	6,6%	6,7%	7,8%	9,1%	8,0%	7,9%	8,1%
Light vehicles traffic generation	1,5	5,4%	10,2%	6,3%	2,2%	7,0%	5,0%	6,5%	4,9%	5,0%	5,9%	6,8%	6,0%	5,9%	6,1%

[a] File employ1.xls, sheet Taffic growth

3.3.6.2 Cross Border Traffic

The year 2012 scenario for cross-border traffic is based on the 1996 matrix shown in Table 3.2.2 above. The overall assumptions on trade growth shown in Table 3.3.1 were applied for year 2012 and transport to and from RSA was calculated. It was assumed that the cross-border traffic to and from the other neighbouring countries was distributed in proportion to the 1996 matrix.

The total transport was converted to number of heavy vehicles based on a 20 tons average in the dominant direction of flow. This resulted in an increase from a total of 140 in the base year 1996 to 263 heavy goods vehicles per day in 2012 as shown in the Table 3.3.5 below. A manual adjustment of this table based on the reasoning in chapter 3.2 was then carried out. This adjustment accounts for additional transport as a result of the Trans-Kalahari and Trans-Caprivi road improvements. The final result is shown in Table 3.3.6.

Table 3.3.5[a] Forecast of Cross Border Transport in 2012. Without improvements of regional network.

Namibia Cross Border Transport. AADT heavy vehicles. Forecast 2012													AADT
Country/	Destination												Heavy
Origin	Ang	Bots	Mal	Moz	Nam	RSA	Swa	Tan	Zam	Zim	Oth	Unk	2-way
Angola	2,7				4,8						0,0		7
Botswana					3,1								3
Malawi													0
Mozambique	0,0												0
Namibia	15,9	4,0		0,0	0,5	77,9	0,3	0,0	8,4	7,4		0,0	114
RSA	1,3				109,3	0,0				0,0	10,7	0,1	121
Swaziland													0
Zambia		0,0	0,0		2,5	0,0				0,0			2
Zimbabwe		0,0			11,0	0,0				0,0			11
Other	0,0	0,0			0,7	2,3				0,0			3
Unknown					0,0							0,7	1
Total													263

[a]File trade.xls, sheet Forecast 2012 trucks

Table 3.3.6[a] Forecast of Cross Border Transport in 2012. Including improvements of regional network.

Namibia Cross Border Transport. AADT heavy vehicles. Forecast 2012													AADT
Country/	Destination												Heavy
Origin	Ang	Bots	Mal	Moz	Nam	RSA	Swa	Tan	Zam	Zim	Oth	Unk	2-way
Angola	2,7				4,8						0,0		7
Botswana					4,1								4
Malawi													0
Mozambique	0,0												0
Namibia	15,9	6,0		0,0	0,5	77,9	0,3	0,0	13,4	12,4		0,0	126
RSA	11,3				109,3	0,0				0,0	50,7	0,1	171
Swaziland													0
Zambia		0,0	0,0		7,5	0,0				0,0			7
Zimbabwe		0,0			16,0	0,0				0,0			16
Other	0,0	0,0			0,7	7,3				0,0			8
Unknown					0,0							0,7	1
Total	30	6	0	0	143	85	0	0	13	12	51	1	341
Base 96	13	6	0	0	65	45	0	0	2	3	3	1	140
Annual %	8%	0%	0%	0%	7%	5%	38%	0%	28%	21%	91%	-3%	9%

The manual adjustment is mainly in increased cross-border traffic through the Trans-Kalahari, about 60 additional vehicles. The overall growth of about 9% annually appears reasonable.

For the year 2000 and 2005 forecasts, linear interpolation was used to determine cross-border traffic.

3.3.6.3 Future development

It is apparent that the long term forecast of economic development requires more thought than is supplied in the above scenarios. A number of Government agencies have been approached and it has been concluded that no long range forecasts are presently available which go further than the NDP1.

However, the need for these forecasts is recognized and it is envisioned that in future it will be possible to obtain employment and trade forecasts exogenous to the traffic forecasting process. Also, development will be monitored by the Central Statistical Office and it will be possible to at least make trend projections of employemt and population. As a result, updating of the traffic forecast will not be as time consuming as this initial effort.

[a]File trade.xls, sheet Forecast 2012

3.4 Road Network and Zones

An important task in the traffic modelling activity is to determine the road network to be included in the model and the delineation of traffic generating zones. The concepts are further explained in Appendix 4.

3.4.1 Road Network

The road network included in the model initially is shown on the map in Figure 3.4.1 on next page. Only the most important parts of the road network are included. In order to test the effects of a few potential road development projects alternative road networks were studied, including or excluding

- A freeway between Windhoek and Okahandja;
- A new road link between Gobabis and Grootfontein; and
- A new road link between Windhoek and Walvis Bay.

Figure 3.4.1 Traffic Model Road Network. Base year 1996.

3.4.2 Traffic zones

The numbers of zones are kept low in order to limit the complexity of the model. This allows the matrix to be displayed as a spreadsheet which increases the transparency of the model and allows for manual calculations. In general the zones use administrative district boundaries which facilitates the collection of data. For major traffic generators or where future major development is planned it has been motivated to include additional zones with borders which do not correspond to the administrative boundaries. One example is Möwe Bay where a new fishing port is being contemplated. The zones are shown below on the map in Figure 3.4.2 on next page.

Figure 3.4.2 Traffic Zones. Base year 1996.

3.4.3 Modifications

The traffic model allows for modifying the network and also for increasing the number of zones. In general there is a relationship between the coarseness of the zone system and the detail of the road network. It is hardly worthwhile to increase efforts on adding links to the road network if the number of zones are not increased as well. While it is fairly uncomplicated to add links, increasing the number of zones has further implications. Particularly it becomes increasingly more difficult to find data to support the forecasting model.

At present a number of databases are being compiled at the DOT as part of the Road Management System. In its final form, all databases shall be connected to a master database to ensure that data are consistent throughout the organisation. Ideally, the forecasting model should therefore be based on the road network in the master road data base and forecasted traffic growth returned to the master database after running the model. The chosen approach is to start with a simple model but allow for a future upgrading to integrate the forecasting model with the overall road management system.

3.5 Traffic Flows Years 2000, 2005 and 2012

3.5.1 Major (Base 1996) Road Network

The base 1996 road network is limited to the trunk road and main roads which carry significant traffic volumes as defined in Map 3.4.1 above. Using counted/estimated traffic for 1996/97 obtained from DOT it was possible to calibrate the distribution matrix to a reasonable accuracy. The 1996 base traffic matrices for light and heavy vehicles were updated to reflect distribution of traffic in the years 2000, 2005 and 2012. For year 2012 the medium growth scenario was used.

A simple growth factor model was used to convert the 1996 base matrices to reflect the forecasting years. Traffic generation growth in each zone was taken from Table 3.3.4. Cross-border movement forecasts were used to establish growth factors in the external zones.

The year 2000, 2005 and 2012 light and heavy traffic matrices were assigned to the network using a simple network algorithm, thus obtaining light and heavy traffic volumes on the trunk roads. Traffic volumes for the base year 1996 and the forecasting years 2000, 2005 and 2012 are displayed on the Figures 3.5.1 through 3.5.12. These forecasts are based on the existing road network and new direct link between Windhoek and Walvis Bay.

3.5.2 Alternative road networks

The following combinations of road network alternatives were compared with the base network:

A. Base network in combination with a Freeway Windhoek - Okahandja and a road link between Gobabis and Grootfontein, but without a direct link between Windhoek and Walvis Bay. A few samples of the resulting traffic volumes in this alternative are presented in Figures 3.5.13 through 3.5.15.

B. Alternative A, but with the direct link between Windhoek and Walvis Bay. Some of the traffic volumes in this alternative can be seen in Figures 3.5.16 through 3.5.18.

The following conclusions may be drawn from the figures:

- Building a freeway - or at least a four lane highway - between Windhoek and Okahandja in the first part of the period 2005 - 2010 would likely postpone the building of a new link Windhoek - Walvis Bay at least until the year 2010.
- With no freeway Windhoek - Okahandja a direct link Windhoek - Walvis Bay may be justified within the period 2000 - 2005. It would also emphasise the need for a new link Gobabis - Grootfontein which may otherwise be postponed until the period 2005 - 2010 (except the section Gobabis - Otjinene which may be justified anyway). The big saving in distance between Windhoek and Walvis Bay which would be created with a direct link, might therefore from an economic point of view have preference. It might also enhance the attractiveness of the Walvis Bay - Maputo Development Corridor.

These conclusions should however be treated with caution and any decision on these major development projects needs to be justified on the basis of more detailed investigations into the future development of traffic.

3.5.3 Low Volume Road Network.

Although the Main and District roads account for almost 90% of the total road nework in terms of length they only carry 30% of the traffic. A simple traffic growth model is therefore used. Input in this model are the EADT link figures calculated for 1991 and 1996 by DOT. Traffic growth was calculated for each road class and maintenance region (See Table 3.5.1 below). Estimates are made separately for heavy and light traffic. However, for low volume roads these data must be used cautiously. The model displays the growth over the time period and calculates the compounded growth rate per annum for the period. It then allows the user to decide whether the compounded growth rate is still valid or if another growth factor should be applied.

The initial effort was seriously hampered due to limited traffic counts available. Only two data points were available for each road link which implies that the calculated growth rate might not reflect long term growth trends. It is recommended that these values are manually “calibrated “ by the road engineers of the different maintenance regions to ensure that better correlations are achieved with actual traffic growth. Those calibrations may to some extent be supported by the regional growth rates given in Table 3.3.4.

The calibration problem will be overcome in future when the TSS is fully operational. The TSS will be able to produce accurate monitoring of traffic growth on the road network. The trends can then be used for planning purposes to predict future traffic on the low-volume road network.

Table 3.5.1 Traffic growth 1991 to 1996 by road class.

See Draft Report

4 Traffic Forecast for Competing Modes

There are several modes of transport competing with road transport, *viz.* air services, railway and sea transport. Based on data from the National Transport Development Plan the traffic volumes have been calculated for the competing modes. The figures are only rough estimates to illustrate the competitive market.

Table 4.1[a] Comparison between modes.

	Goods		Passengers	
	Tons	Tons*km	Pass.	Pass.*km
	10^6	10^9	10^6	10^9
Rail	1,76	1,08	0,12	0,05
Domestic Air	0,00	0,00	0,17	0,07
Bus			0,36	0,07
Trucks	6,60	0,66		
Cars			8,00	0,40
modes.xls				

Road transport is the dominant mode. However, rail is still the backbone of goods movement in respect of long haulage of bulk commodities from Walvis Bay and from the mining districts.

The future of rail traffic is however quite bleak. Goods transport has been rather stable the last five years reflecting the stagnation of the mining sector. The opening of the extended cement factory in Otjiworongo will most likely reduce goods movement on rail. At present about 0.2 million tons of cement are imported annually from RSA.

The scenarios for the transport forecast suggests that the growth industries are not within the sectors using rail transport. This means that rail transport will lose market shares to road transport. Provided that the primary industries remain stable, railway transport should be able to remain at the same level as at present. An initial drop in goods transport is however expected when the new cement factory starts to produce.

Major developments, such as the start of new mining operations in Namibia or neighboring countries may of course necessitate a revision of these forecasts. Neither of these developments is expected, however, to have any major impact on the development of road transport.

[a]File mode.xls, sheet Split. Rough calculations based on fuel consunption and assuming average trip lengths.

Passenger traffic by rail has been growing steadily the last few years and is expected to soon reach pre-independence levels. The number of passengers is however sensitive to the pricing policy. Revenue contributions from passenger traffic has been steadily falling since independence suggesting that the last years´ increase in passenger traffic has been at the expense of revenue.

The road user charging system will in the short term result in higher tariffs for road transport. In the long run however, it should contribute to a more economical road network and thereby increase the competitive edge of road transport.

[1] National Transport Development Plan. Step 1. Volumes 1 - 3. SOGREAH Ingenierie/SYSTRA, December 1996
[2]Economic Evaluation Manual. Department of Transport, updates 1993 -1994.
[3]First National Development Plan. Volumes 1 - 2. National Planning Commission, Namibia.
[4]Development of a Computerised Traffic Surveillance System. Phase 1 Report. Repsa Tech CC for Department of Transport, March 1995.
[5]Republic of Namibia 1991 Population and Housing Census. Reports A and B, 8 volumes. National Planning Commission, August 1993.
[6]National Transportation Master Plan Study. Draft Final Report on Road User Charges. SWECO(KM)/VKE for Department of Transport.
[7]SADC/SATCC Border Post Traffic Survey. Transport and Communications Integration Study and Cross Border Road User Charges, January 1997.
[8]A Survey of Heavy Vehicles Crossing the Namibia - South Africa Border. Final Report. CSIR, Pretoria, May 1995.
[9]Transport and Communications in Namibia. Prepared for the Ministry of Works, Transport and Communications, Republic of Namibia, March 1990.
[10] Measuring the Impacts of Freight Transport Regulatory Policies. V. Prins and M. Schultheis in Transportation Research Record 1154.
[11]Feasibility Study. Gobabis to Aranos Link Road. Windhoek Consulting Engineers for Ministry of Works, Transport and Communication, 1994.
[12]Pre-Feasibility Study for the Oranjemund Link Road. Bührmann and Partners Consulting Engineers for Department of Transport, March 1994.

GUIDELINE FOR FORECASTING OF ROAD TRAFFIC IN NAMIBIA

Version 3
September 1998

Prepared for:
Ministry of Works, Transport and Communication
Government of the Republic of Namibia

SCOPE

The main purpose of this guideline is to provide a methodology for the generation of road traffic forecasts for Namibia. The emphasis of this approach is on maintenance of and improvements to the present road network. However, the procedure used for the calibration of the forecasting models allows for expansion of the network and zoning system as well as the refinement of the trunk road demand model to include other areas. Demand models for specific areas may also be developed using this approach.

Due to Namibia's well developed road network, particularly in relation to its small population and generally low traffic volumes, two separate approaches for traffic forecast are recommended, namely:

- A more refined technique on the major road network
- Historical trend analysis for the low volume road network.

This guideline is based on Task 17 of the Namibia National Transport Master Plan Study (NTMPS) undertaken by KM International and VKE Engineers on behalf of the Ministry of Works, Transport and Communication, Namibia, with financial assistance from the Swedish Government.

Guidelines for Traffic Forecast: Version 3, includes:

- Data collection
- Forecast procedures
- Running the Models
- Improvements to the Models
- Examples of outputs from the process of forecasting traffic

The application of the forecast models will be dependent of the organisation and resources allocated to the new arrangements in the road sector currently under implementation. The demand model to be used on the major road network is primarily to be seen as a tool for strategic planning which is expected to be the responsibility of the downsized MWTC. The Ministry will likely not have their own expertise to use the forecast model. The actual work is therefore expected to be assigned to private consultants who are familiar with the methodology. The computer software necessary for the demand model is a standard type available through a number of consultants in the region. The Ministry staff only need to be familiar with the requirements and expected performance from using the model. It can be used for full scale forecasts on a national level in future or for updating or minor changes of the forecast made as part of the NTMPS.

The historical trend analysis model for the low volume network is expected to be used primarily by the new Roads Authority and its consultants on a regular basis for economic evaluation and feasibility studies on road improvement projects or for road maintenance planning.

CONTENTS

INTRODUCTION

The traffic forecasting requirements for any country must be determined by the nature of the planning process in place. The focus in Namibia will be on maintenance and improvements of the present network, rather than investments in completely new links. The main use of the forecasts will therefore be as an input into a maintenance management system and for forecasting the need for pavement upgrading. Traffic forecasts will also be used for road user revenue projections.

Detail on the background to this manual are provided in the report: " Final Report on Traffic Forecast, KM/VKE, 30 September 1998". The information contained in this document is the specific process that needs to be followed to generate the traffic forecasts. Specific topics that will be discussed are:

Module1 : Collecting data

Module 2 : Forecast procedure

Module 3 : Running the Models

Module 4 : Improving the Models

Module 1: Collecting data

The data collection efforts for planning and management purposes are currently being streamlined and moulded around specific future applications. This process forms the basis on which the forecast models were developed.

The crucial items for forecasting are:

- Long term scenarios
- Employment statistics
- Traffic counts at permanent stations
- Coverage counts on EADT 1991 and 1997
- Road network
- Cross-border movements

This section of the guideline discusses each of these specific data items which need to be collected in order to use the models for forecasting purposes.

1.1 Long term scenarios

Long term scenarios are needed to test the effect of various parameters on the traffic volumes of the road network. Since transport is a derived demand, these scenarios should be integrated with the macro-economic framework established for Namibia, such as in the Namibia Development Planning process. The aim is to focus on realistic policies and outcomes for future periods.

Potential sources of information are:

- Policy and Strategic Planning documentation including :
  - White Paper on Transport Policy
  - Corporate plans of the Ministry of Works, Transport and Communication (MWTC), the future Roads Authority and Road Fund Administration
  - Documentation on Strategic Plans for transportation and related sectors which might influence the demand for transport and infrastructure
- National Development Plans and Programs, such as the First National Development Plan for Namibia
- Project preparation and feasibility study reports

Based on these documentations, the specific implied growth for each of the following parameters needs to be identified to allow the conversion into traffic growth for each future scenario:

- Population growth
- Economic growth (GDP)
- Growth in employment
- Changes in trade patterns
- Import and export growth

It is useful to summarise these data in a table containing the base information, under the identified parameters (i.e. employment, etc) and the implied growth of every parameter for each scenario.

Table 1.1 below shows an example from the NTMPS.

Table 1.1[a] Summary of scenarios.

		Scenarios		
PARAMETERS	All Scenarios	Low Growth	Medium Growth	High Growth
	Base 1996	Forecast 2012	Forecast 2012	Forecast 2012
Population (000)	1 650 000	2 600 000	2 650 000	2 700 000
Employment (000)	424 000	700 000	854 000	900 000
GDP N$ Million (1996 Prices)	13 886	25 000	35 000	40 000
Exports N$ Million(1996 Prices)	6 840	12 000	14 000	15 000
Imports N$ Million(1996 Prices)	8 032	13 000	16 000	20 000
RSA Trade (Percent of total trade)	80%	75%	70%	65%
GDP/Employed	32 750	35 714	40 984	44 444
Trade/GDP	107%	100%	86%	88%
Employment/Population	26%	27%	32%	33%

1.2 Employment

Historical data on employment need to be collected, since employment is recommended to be used as the indicator of economic growth for traffic forecasting purposes on the major road network. The Central Statistical Office (CSO) started in 1996 to update these values annually.

These employment statistics are provided for each region of Namibia and can be obtained from the CSO. This regional information is broken down by economic sector. A table to reflect the regional employment per economic sector for all years of the study period should as such be compiled. This aggregated information will be expanded to reflect employment for future time periods and then to be disaggregated into the 39 internal zones.

The process to be followed to generate the forecast factors for each parameter is discussed in Section 2.1hereafter.

[a]File gdp, sheet Summary

1.3 Traffic counts on permanent stations

The Department of Transport counts traffic on a regular basis on the proclaimed road network. All traffic counts are executed by means of automatic counting machines connected to permanent induction loops capable of separating between heavy and light vehicles. These traffic counts represent the most reliable information available for forecast purposes. These data need to be collected for each road in the identified road network and will be applied in the development of multipliers used to calculate growth factors for traffic volumes. The annual growth rates for the study period will be calculated using these multipliers.

1.4 Coverage counts or EAADT for 1991 and 1996-97

The Traffic Surveillance System (TSS) is based on a PC hardware and Progress Software platform. The approach for data collection is to use mobile machines to perform non-classified coverage counts on all 2 600 links on the road network during a four year cycle. These data are analysed and the AADT are calculated for each road.

Estimated Average Annual Daily Traffic (EAADT) is also determined by the DOT for all road links in the country. Regional engineers and supervisors estimates traffic volumes based on observations during blading operations, traffic counts and general knowledge of the road network. Previous exercises were completed in 1991 and 1997.

These data need to be collected to allow backcasting, recalibration of the base year model, identifying specific areas of growth that need special attention, as well as the refinement of the base road network.

1.5 Road network & traffic zones

The road network as included in the base model is shown in Figure 1.1.

FIGURE 1.1 BASE ROAD NETWORK

Only the major part of the network and links, which where identified as being important roads for future developments, were included. The 1996 base network therefore includes only existing roads, including the following links of future importance:

- The link between Oshakati and Rundu
- The link between Leonardville and Gobabis

When using the model for forecasting purposes, the 1996 base year model need to be evaluated and updated to reflect the major road system for Namibia at the time of forecasting.

This also implies that the traffic zones for the base network needs to be revisited to ensure that specific future development nodes and the primary influence areas are included as separate traffic zones.

1.6 Cross-border movements

Trends and shifts in cross-border movements between Namibia and the neighbouring countries have to be established to allow evaluation of the internal-external trip matrix. The 1996 internal-external base matrix was developed using the 1996 SADC cross-border survey data. Major changes and developments that might imply changes to the movements between internal zones and external entrance points have to be established.

Issues such as the completion or addition of new international highway links (example Trans Caprivi Highway) might have major impacts in terms of traffic shifts to other routes. Other aspects that will have an impact on cross-border movements that need to be taken into account is:

- Cross-border procedures
- Road user charging systems
- Developments of new ports locally and in neighbouring countries
- Political developments in neighbouring countries
- Infrastructure developments
- Significance of border trades

The specific impacts of changes from the Status Quo (i.e. 1996 base year model) have to be quantified for inclusion in the updating of the base model and, calculation of the growth factors for forecasting of external movements.

Module 2 will discuss the prediction of growth factors for forecasting purposes.

Module 2: Forecast procedure

Forecasts of specific parameters are important inputs into the development of future traffic scenarios. These parameters are needed to expand the base data to reflect the impacts of future scenarios.

The previous section highlighted the base data that need to be collected to allow the calculation of growth factors for these parameters. The identified parameters are:

- Employment
- Cross-border traffic
- Future road network and zoning system

The forecast of traffic volumes on the low volume road network is based on historical growth trends and this will be discussed in section 3.5.

The next section provides a description of the process to forecast growth factors for traffic, based on specific identified parameters.

2.1 Employment

The employment growth in each region is the basis for calculating the growth of traffic in the internal zones. (Zones 1 to 39) The employment growth for each of the thirteen regions are calculated as a first step. This data is then disaggregated into the 39 traffic zones in the next step.

The procedure to forecast employment for each of the regions is as follows:

1. Collect historical data on employment for each of the thirteen regions from the CSO, i.e., employment per region per economic sector. (Discussed in Module 1)

2. Calculate employment growth for each region by using the total employment for the region.

   Formula 2.1:

   Insert

   With

   EGR_i = Employment growth (as %) for region i, i= 1………..13.

   TE_iYF = Total employment for region i for first year of study period (i.e.,1991 if period is 1991-1995)

   TE_iYL = Total employment for region i for last year of study period (i.e. 1995 if period is 1991-1995)

3. Translate the growth of employment in each region into growth in traffic volumes, making a distinction between light and heavy vehicle, by using the following procedure.

Translation procedure:

Step 1:

Calculate the growth multipliers for all the different modes of transport for each scenario for each region.

Formula 2.2:

Insert

With

k = scenario number (k=2000, 2005, 2012)
i = region (i= 1 ……..13)
j = mode of transport (with j= light, heavy and bus if applicable)

GM_{kij} = Growth multiplier for scenario k in region i for mode j

TGR_j = Traffic growth rate for mode j

EGR_i = Employment growth rate in region i (see Formula 2.1)

The formula to calculate the traffic growth rate for mode j is:

Formula 2.3:

Insert

with

TGRj = Traffic growth rate for mode j

AT_jYF = Average traffic for mode j for first year of study period

AT_jYL = Average traffic for mode j for last year of study period

The formula for calculating average traffic for mode j is:

Formula 2.4:

Insert

with
h = permanent counting station

$AADT_j$ = Average Annual Daily Traffic for mode j at permanent counting station h

If AADT is not available the EAADT values may be used.

Step 2:

- Determine the growth in employment for the future scenarios under consideration by:

  - Determine the growth in GDP for the future periods from the long term scenario as discussed in section 1.1
  - Calculate the growth of each economic sector for the future period by distributing the forecasted GDP growth according to the proportional contribution of each economic sector to GDP of the base year
  - Calculate the proposed future employment by adjusting the regional total employment. This entails the applying of the growth proportionally in each economic sector on the regional employment per economic sector. (CSO data for new base year)
  - Determine the % growth in employment by comparing the total employment for the region with the new base year data (use Formula 2.1)

- Manually fine tune the regional projected growth for employment through interactions with experts such as personnel from the Ministry of Regional and Local Government and Housing to ensure the applied future employment is realistic.

- Convert the employment growth to growth in traffic volumes by:

  Formula 2.5:

Insert

with

$TGFT_{kij}$ = Total Traffic Growth factor for scenario k in region i for mode j

GM_{kij} = Growth multiplier for scenario k in region i for mode j

EGR_i = Projected Employment growth rate in region i

- Disaggregate the regions into all traffic zones, i.e. 13 regions to 39 traffic zones. Allocate an equal value as a traffic growth factor to all traffic zones in the region.

Step 3:

Compile a table indicating for each future scenario the growth in employment and calculated future growth factors for all transport modes, for each traffic zone. Tables 2.1, 2.2 and 2.3 below show examples of outputs from the NTMPS.

Table 2.1[a] Projected employment growth of economic sectors.

Projected annual employment growth									
Employment (000) and		Base 1996		Forecast 2000		Forecast 2005		Forecast 2012	
annual growth in preceding period								Medium	
Region/Industry		Empl.	Growth	Empl.	Growth	Empl.	Growth	Empl.	Growth
Agricultural (Comm.)		42,00		47,00	2,9%	51,70	1,9%	52,25	0,2%
Agricultural (Subsistence)		159,00		179,00	3,0%	196,90	1,9%	216,59	1,4%
Fishing		9,00		13,00	9,6%	13,00	0,0%	13,00	0,0%
Diamond mining		5,00		3,00	-12,0%	3,45	2,8%	3,97	2,0%
Other mining		7,00		9,00	6,5%	11,70	5,4%	15,21	3,8%
Manufacturing		11,00		17,60	12,5%	35,20	14,9%	88,00	14,0%
Fish Processing		4,00		8,00	18,9%	12,00	8,4%	20,40	7,9%
Meat Processing		4,00		6,40	12,5%	9,60	8,4%	16,32	7,9%
Electricity and water		2,00		2,00	0,0%	2,60	5,4%	3,64	4,9%
Construction		26,00		35,00	7,7%	52,50	8,4%	89,25	7,9%
Trade		41,00		55,00	7,6%	82,50	8,4%	140,25	7,9%
Hotels and Restaurants		4,00		5,37	7,6%	9,66	12,5%	24,15	14,0%
Transport and comm.		12,00		14,00	3,9%	21,00	8,4%	35,70	7,9%
Finance and business services.		10,00		12,00	4,7%	15,60	5,4%	26,52	7,9%
Social and personal services		10,00		12,00	4,7%	15,60	5,4%	21,84	4,9%
General government		75,00		76,00	0,3%	79,80	1,0%	83,79	0,7%
Other producers		3,00		3,00	0,0%	3,15	1,0%	3,31	0,7%

The regional growth scenario has been discussed with the Ministry of Local Government and Housing. Two factors may need additional attention. The development in the northern regions may be faster due to its closeness to the Angola market. In these regions there is a comparative advantage which is not accurately reflected in the historical data. Another concern is the growth constraints of Windhoek which relate to a shortage of land and water for further development.

[a] File employ1.xls, sheet Summary

Table 2.2[a] Forecast of employment in Regions

Forecast of employment in Regions														
Employment (000)														
Region	Caprivi	Erongo	Hardap	Karas	Khomas	Kunene	Ohang-wena	Oka-vango	Oma-heke	Omu-sati	Oshana	Oshi-koto	Otjozu ndjupa	SUM
Total employment year 2000	33,36	30,89	20,35	24,05	79,82	24,96	48,18	39,98	16,92	63,65	39,78	35,78	39,65	497,37
Employment 1996	28,92	23,75	17,27	22,70	66,45	21,88	40,67	35,12	14,83	54,57	33,30	30,60	33,94	424,00
Annual growth	3,6%	6,8%	4,2%	1,5%	4,7%	3,3%	4,3%	3,3%	3,4%	3,9%	4,5%	4,0%	4,0%	4,1%
Total employment year 2005	38,62	38,34	25,90	30,04	108,66	29,51	58,14	46,13	20,01	75,71	50,86	43,61	50,43	615,96
Employment 2000	33,36	30,89	20,35	24,05	79,82	24,96	48,18	39,98	16,92	63,65	39,78	35,78	39,65	497,37
Annual growth	3,0%	4,4%	4,9%	4,5%	6,4%	3,4%	3,8%	2,9%	3,4%	3,5%	5,0%	4,0%	4,9%	4,4%
Total employment year 2012	47,41	53,64	36,99	42,07	174,65	37,71	76,91	55,73	25,33	97,48	73,63	58,56	74,08	854,18
Employment 2005	38,62	38,34	25,90	30,04	108,66	29,51	58,14	46,13	20,01	75,71	50,86	43,61	50,43	615,96
Annual growth	3,0%	4,9%	5,2%	4,9%	7,0%	3,6%	4,1%	2,7%	3,4%	3,7%	5,4%	4,3%	5,6%	4,8%

Source Household Census 1991 Table E06

[a]File employ1.xls, sheet Summary regions

Table 2.3[a]. Annual employment and traffic generation growth.

Annual employment and traffic growth															
Time period	Multi-plier	Caprivi	Erongo	Hardap	Karas	Khomas	Kunene	Ohang-wena	Oka-vango	Oma-heke	Omu-sati	Oshana	Oshi-koto	Otjozon djupa	SU M
1991 - 1996 annual growth															
Annual employment		4%	3%	3%	3%	3%	4%	4%	4%	3%	4%	4%	3%	3%	3%
Heavy vehicles traffic generation	2,4	9,0%	7,5%	7,4%	6,8%	8,1%	8,5%	9,3%	9,3%	6,0%	9,4%	10,1%	6,6%	6,2%	8,2%
Light vehicles traffic generation	1,7	6,7%	5,6%	5,5%	5,0%	6,0%	6,3%	6,9%	6,9%	4,5%	7,0%	7,5%	4,9%	4,6%	6,1%
1996 - 2000 annual growth															
Annual employment		3,6%	6,8%	4,2%	1,5%	4,7%	3,3%	4,3%	3,3%	3,4%	3,9%	4,5%	4,0%	4,0%	4,1%
Heavy vehicles traffic generation	2,2	8,0%	14,9%	9,2%	3,2%	10,3%	7,4%	9,5%	7,3%	7,4%	8,6%	10,0%	8,8%	8,7%	9,0%
Light vehicles traffic generation	1,6	5,8%	10,9%	6,7%	2,3%	7,5%	5,4%	6,9%	5,3%	5,4%	6,3%	7,3%	6,4%	6,3%	6,5%
2000 - 2005 annual growth															
Annual employment		3,0%	4,4%	4,9%	4,5%	6,4%	3,4%	3,8%	2,9%	3,4%	3,5%	5,0%	4,0%	4,9%	4,4%
Heavy vehicles traffic generation	2,1	7,6%	14,3%	8,8%	3,1%	9,9%	7,0%	9,1%	6,9%	7,0%	8,2%	9,5%	8,4%	8,3%	8,5%
Light vehicles traffic generation	1,5	5,4%	10,2%	6,3%	2,2%	7,0%	5,0%	6,5%	4,9%	5,0%	5,9%	6,8%	6,0%	5,9%	6,1%
2005 - 2012 annual growth															
Annual employment		3,0%	4,9%	5,2%	4,9%	7,0%	3,6%	4,1%	2,7%	3,4%	3,7%	5,4%	4,3%	5,6%	4,8%
Heavy vehicles traffic generation	2,0	7,3%	13,6%	8,4%	2,9%	9,4%	6,7%	8,6%	6,6%	6,7%	7,8%	9,1%	8,0%	7,9%	8,1%
Light vehicles traffic generation	1,5	5,4%	10,2%	6,3%	2,2%	7,0%	5,0%	6,5%	4,9%	5,0%	5,9%	6,8%	6,0%	5,9%	6,1%

[a]File employ1.xls, sheet Taffic growth

2.2 Cross-border traffic

The forecast of cross-border traffic is greatly simplified by using the data from the road user charging system which collects fees at the borders. This system is expected to be operational by the year 2000.

The suggested procedure with the Road User Charging System data as a basis, entails:

- Down-load historical data for external movements from the Road User Charging System for all modes of transport (number of vehicles and tonnage hauled). N.B Only heavy vehicles will pay cross-border charges. Hence, information on light traffic movements should be obtained from the data base at the Office of the Prime Minister, as compiled by Immigration or Customs Excise. This data collection should be done at least on an annual basis as a general source of information for the MWTC and the Roads Authority.
- Identify the cross-border movements between Namibia and all neighbouring countries. Differentiate between movements into and out of Namibia.
- Compile a table with data on the number of vehicles and tonnage hauled entering and leaving Namibia for each border post.
- Calculate proportional distribution for the border posts in terms of tonnage (heavy vehicles) and number of vehicles (light vehicles).
- These will represent the new base year proportions.
- Identify the growth factors for trade for the future time period for heavy vehicles and tourism for private transport from the long term scenario.

The application of these factors on the base data will be discussed in module 3.

2.3 Future road network and zoning

The future road network used for forecasting purposes will largely depend on developments in other economic sectors, regions, etc. The base road network need to be evaluated for its relevancy for the new updated base year.

The following factors will play an important role in the finalisation of the new updated base year road network:

- include roads that have been upgraded i.e., gravel roads which have been surfaced
- important roads in line with development plans for specific regions need to be identified for inclusion in the road network
- new road links should be added i.e. completely new links, such as the one between Gobabis and Grootfontein.

The road network has to be closely related to the proposed traffic zones for the new base year.
The zoning system for the new base year has to reflect the level of detail that is to be achieved in the model. The base model traffic zones need to be evaluated for relevancy. Issues that have to be considered include:

- Areas that were highlighted for developments might have changed, etc.
- Aggregation of zones might also be essential to reflect actual primary activity nodes.
- Refinement of the zoning system will depend on the road network and identified development nodes.

Module 3: Running the Models

The applications of the model for the major road network (Sections 3.1 – 3.4) and the low volume roads (Section 3.5) are discussed separately.

Major Road Network Model:

The model for forecasts of traffic on the major road network is available both in the ”manual-spreadsheet” format as well as in computerised format. The reason for this is the need for a computerised package to assist the calibration process. This has been converted to a manual ”spreadsheet” model which will supply similar outputs.

This section of the guideline will discuss the manual approach and will only refer to the computerised model where applicable.

3.1 Growth factors for zones

The first step in using the model is to enter the traffic growth factors for each mode under consideration into the model. The methodology for calculation of these values are discussed in Module 2. A distinction is made for the application of these growth factors for light and heavy vehicles.

3.1.1 Light vehicles

The growth factors for the zones are presented as a single growth factor matrix i.e. a row total value for each zone. This implies that the same growth factor will be applied in each cell according to the base year proportions. The factor for the internal zones is based on employment, and tourism for light traffic of the external zones.

3.1.2 Heavy vehicles

The internal growth factors for heavy vehicles also represent traffic growth due to increased economic activity (employment is used as measure of economic development). Growth in trade, based on historical patterns is used for the heavy traffic in the external zones.

3.2 Growth factor model

The manual growth factor model consists of a Workbook in Excel with linked spreadsheets which automatically calculate the implied trip matrix for the different growth scenarios after the input of the growth factor for the zones.

The model consist of an Excel workbook.

- Sheet 1 represents the base year matrix.
- Sheet 2 represents the growth factors for each zone.
- Sheet 3 redistribute the expanded row tables according to the base year proportions.

The procedure for application of the manual model is:

1. Go into the ”lightmodel.XLS” file
2. Update base matrix, i.e. the zoning, etc.
3. Type the different growth factors into the ”**Totals**” sheet for each scenario
4. The model will automatically calculate the new origin totals for each zone and redistribute it for each scenario according to the base matrix proportions.

The procedure for heavy vehicles is similar, using the ”heavymodel.XLS” file.

The mentioned Excel files can be obtained from the Department of Transport or the Roads Authority.

3.3 Assignment

The base year network for the major road network is a very coarse network. This ensures that no technical assignment of the traffic between two zones are needed. The assignment of traffic into the network therefore implies a manual procedure. It is recommended that a person who has a broad feel for travel patterns executes this process since alternative routes do exist to some destinations. An all-or-nothing assignment procedure is recommended unless information is available on the split of traffic volumes amongst available routes. The procedure entails:

- Plot the base network from Caddie drawing: ”Namib_a3.drw”
- Add the traffic volumes between each two zones onto the network, using different color pens. A simplification of the procedure can be achieved by excluding all small values in the trip matrix.
- Determine full link volume by adding the inter-zonal values.

These values can then be displayed graphically.

3.4 Display traffic volumes

The display of the traffic volumes on a map via the manual procedure is one of the most flexible and maybe most time consuming efforts in the production of traffic forecasts.

The suggested approach is:

- Plot the base network and zoning from the Caddie drawing : ”Namib_a3.drw

- Add traffic volumes either as value or band width reflecting the traffic volume onto each link
- Plot outputs

An alternative is to link the data output file with a GIS and display the data via the facilities available to do so.

The computerised model allows easy automatic display of the network, zoning system and the assigned traffic volumes on the road segments either via writing the actual volume on the road link or by indicating it as a band width on the specific link.

An example of a map produced through the computerised model is shown on next page.

Low Volume Road Model

3.5 Trend forecast for low-volume roads

The low volume road network in Namibia represents 80 % of the network, and carries only 20 % of the traffic. An approach of calculating historical trends for these roads, which include all district roads and the majority of the main roads, was seen as the most appropriate approach to calculate future traffic volumes. The first effort had only two data points available.

The future availability of data will change as the TSS will supply the data to be used for future purposes. The procedure developed for forecasts assumes that sufficient historical data will be available to calculate historical growth rates. It thus allows the user to apply specific growth rates if it is so required for a specific road.

The model for the low volume roads is set up to allow the user the freedom to either use the disaggregated data i.e. each road separately, or aggregated according to road class, surface type and maintenance region. The model consists of an Excel Workbook consisting of the following sheets:

Sheet 1: Raw data for all roads links according to surface type, road class and maintenance region for all years for which historical data is available (as from the TSS).

Sheet 2: Summary table per road, indicating the road number, road class, surface type and maintenance region. The total growth in traffic over the data period for each road is automatically calculated.

Sheet 3: Summary table indicating traffic growth aggregated according to the road class, surface type and maintenance region.

Sheet 4: New base year, according to data for each road with growth factors from sheet 2 applied for each scenario. Growth factors applied as compounded growth for each future scenario.

Sheet 5: New Base year, summarised according to sheet 3, with growth factors in sheet 3 applied as compounded growth to calculate future traffic.

The file ”Lowlight.XLS” is the workbook for light vehicles and ”lowheavy.XLS” for the heavy vehicles. Examples of printouts from sheets 1-5 of the workbook for light vehicles are presented in the next five pages.

The mentioned Excel files can be obtained from the Employer.

The procedure for forecasts will entail:

- Update[a] sheet 1 link data for each road, from the TSS data base to include all the years for which data is available.
- Update[b] summary table 2 to reflect the summarised road data by calculating an average traffic volume for each road.
- All growth factors will be automatically calculated (if procedure described in Footnote a and b are followed).
- All summary tables will be automatically generated.
- Rename the forecast year given in sheet 4 and sheet 5 to reflect new scenario years.

[a] Insert all new road link data before the last value for each category, i.e. somewhere between first row in table and last row in table for each category.

[b]
- Add the first year date in column named 1991 i.e. old Base year
- Add the new base year data in column named 1997 i.e. new base year
- Insert any additional data in columns **before** new base year data, i.e. between old Base year and new base year

Module 4. Improving the models.

The quality of any model is as good as the quality of the information added into the system. The most important improvements to the models are therefore to ensure that the quality of input data are sound. Measures that can be taken to ensure this, is to:

- Keep the TSS fully operational and maintained
- Ensure that the CSO update the employment statistics annually
- Maintain and manage all counting programmes
- Do follow-up counts after completion of road building projects to compare forecast diversions of traffic with actual diversions.
- Analyse Road User Cost data bases to monitor shifts in cross border movements.
- Start a program to monitor economic developments and make economic development forecasts for regions.

Other important aspects which relate to the model itself will be discussed separately in the next section.

4.1 Back-casting

A means to re-calibrate the major network model is to use the model to predict historic traffic and compare that with the actual traffic movements on the road network. A factor can then be calculated and applied on the base year values to ensure a better correlation between actual values and forecast values. Adjustment of these load factors on the network ensure that the model may be fine tuned to provide closer predictions of actual traffic for future time periods.

4.2 Adjusting multipliers

The multipliers in the major network model are used to forecast the growth in traffic for the specific scenario according to the actual mode distribution. These multipliers can be adjusted by re-calibrating the employment and traffic growth for the different modes of transport based on actual traffic and employment values.

4.3 Refining the zones

The current zoning system represents a coarse macro level model which is closely related to the simplistic network system used as a base network. The current number of internal zones is 39. Each of these zones have a primary town identified for that zone. This zoning system can be further refined by:

- Identifying additional primary activity nodes within the existing coarse zones.
- Determine the primary influence area of this node.
- Divide existing zone to represent this new additional area.

A very important issue to keep in mind is that data to support this disaggregration is an essential pre-condition for further refinement. This implies that the following data have to be available for each new zone: employment, traffic, information on primary economic activity to link that with forecast GDP growth, etc.

4.4 Refining the network

The current road network consists of the trunk roads and only those main roads that supply access to areas identified as potential development nodes. This network can be refined by including other main and even district roads for which traffic data are available on a continuous basis.

The more complex the network and zoning system becomes, the higher the need will become to use more sophisticated computerised models. All the base data for 1996 and the forecast matrixes are currently available in EMME/2 format and can be easily adjusted to reflect new zones and a refined road network.

4.5 Application of a full growth factor matrix

The model can be further refined by applying the growth factor matrix to both the row and column tables, i.e. not as a single growth factor matrix. This will imply that an iteration will be essential to equalise the row and column totals. Different methods are readily available to ensure a fast conversion. It is suggested that this methodology be added into the spreadsheets to overcome the manual calculation of this procedure.

4.6 Calibration of the low volume roads model

The results of calculating the growth factors for this model provided strange results since only two data points were available to base calculations on. It is suggested that this data be fed back to the regional engineers responsible in the different maintenance regions. The Regions can do a ”manual” adjustment of the growth factors based on their experience and knowledge of the areas. This information can then be fed back into the model to enhance the initial forecasting effort. The regional traffic growth factors indicated in the Final Report on Traffic Forecast by KM/VKE, September 1998, Section 3.3, may support the calibration.

APPENDIX A : HARDWARE AND SOFTWARE REQUIREMENTS

This appendix provides an indication of the minimum hardware and software necessary to effectively use the forecast model.

Manual method:

The hardware requirements to do the display of the outputs for the manual procedure are determined by the Caddie software.

The following represents the minimum requirements for use of Caddie.

TABLE 5A.1: MINIMUM COMPUTER REQUIREMENTS FOR CADDIE

	Program version	PC type	RAM
Dos	4.2	486	8 Mb
Windows	5.2	Pentium	16 Mb

Computerised method:

The only limitation in the overall approach for the forecast model for Namibia in terms of hardware is associated with the EMME/2 model. It is, however, suggested that the MWTC appoint a consultant with a license to use EMME/2. This will imply that the hardware, software and required expertise base is already in place.

In order to install EMME/2, an Intel i386/i486 based computer is needed with the following additional requirements:

- Running under MS-DOS, version 3.3 or later
- At least 15 Mb of disk space on one disk, although this does not take into account the amount of space needed for the user's data bank
- High-resolution graphical adapter and monitor, a graphics mode providing a minimum resolution of 800H X600V dots per screen is recommended
- A Microsoft compatible mouse or graphic tablet (digitizer)
- A mathematical processor Intel i387
- One 1.44Mb (HD) 3.5" diskette drive
- At least on parallel port

The minimum RAM requirements depend upon the size of the licence. The specifications are presented in the following table.

Size (#of zones)	Minimum required	Minimum recommended
200	2 Mb	2 Mb
400 - 800	3 Mb	4 Mb
1 000 – 1 600	5 Mb	8 Mb
1 800 – 2 000	6 Mb	8 Mb
2 200 – 2 800	8 Mb	10 Mb

Software requirements :

The following software packages are needed to use the proposed models for traffic forecasting:

- Windows 95
- Microsoft Excel version 7.0
- MS Dos version 3.3 or later
- Caddie

The software selected is readily available.