Traffic Data Collection and Analysis

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ROADS DEPARTMENT

Under the policy direction of the Ministry of Works and Transport, Roads Department is responsible for providing an adequate, safe, cost-effective and efficient road infrastructure within the borders of Botswana as well as for facilitating cross-border road communications with neighbouring countries. Implied in these far-ranging responsibilities is the obligation to:

1. ensure that existing roads are adequately maintained in order to provide appropriate level of service for road users;

2. improve existing roads to required standards to enable them to carry prevailing levels of traffic with the required degree of safety;

3. provide new roads to the required geometric, pavement design and safety standards.

The Department has been vested with the strategic responsibility for overall management of the Public Highway Network (PHN) of some 18, 300 km of roads. This confers authority for setting of national specifications and standards and sheared responsibility with the District Councils and Department of Wildlife and National Parks for the co-ordinated planning of the PHN.

Roads Department is also responsible for administering the relevant sections of the Public Roads Act, assisting local road authorities on technical matters and providing assistance in the national effort to promote citizen contractors in the road construction industry by giving technical advice wherever possible. This task is facilitated by the publication of a series of Technical Guidelines dealing with standards, general procedures and best practice on a variety of aspects of the planning, design, construction and maintenance of roads in Botswana that take full account of local conditions.

Guideline No. 1 **The Design, Construction and Maintenance of Otta Seals (1999).**
Addendum to Guideline No. 1 Seminar Proceedings (June, 2000).

Guideline No. 2 **Pavement Testing, Analysis and Interpretation of Test Data (2000).**
Addendum to Guideline No. 2 Seminar Proceedings (January, 2002).

Guideline No. 3 **Methods and Procedures for Prospecting for Road Construction Materials (2000).**
Addendum to Guideline No. 3 Seminar Proceedings (April, 2002).

Guideline No. 4 **Axle Load Surveys (2000).**
Addendum to Guideline No. 4 Seminar Proceedings (January, 2002).

Guideline No. 5 **Planning and Environmental Impact Assessment of Road Infrastructure (2001).**

Guideline No. 6 **The Prevention and Repair of Salt Damage to Roads and Runways (2001).**
Addendum to Guideline No. 6 Seminar Proceedings (April, 2002)

Guideline No. 7 **Technical Auditing of Road Projects (2001).**
Addendum to Guideline No. 7 Seminar Proceedings (June, 2003).

Guideline No. 8 **The use of Silcrete and Other Marginal Materials for Road Surfacing (2002).**
Addendum to Guideline No. 8 Seminar Proceedings (June, 2003).

Guideline No. 9 **Traffic Data Collection and Analysis (2003).**

FOREWORD

Despite the different core areas of road use to which these Guidelines pertain, the ultimate objective is to ensure proper, adequate, safe economical and efficient management of the national road network. It is worth pointing out that, without physical access to jobs, health, markets, education and other amenities, the quality of life inevitably suffers, growth stagnates and poverty reduction cannot be sustained. These Guidelines, therefore, will enable adoption of a common approach and methodology for collection of traffic data by the respective authorities, while at the same time ensuring that data so collected fits the purpose for which it is intended to serve.

The approach as provided for in these Guidelines, will enhance proactive action by planners, implementing bodies and other beneficiaries in providing the necessary advise to the various authorities on matters of statistical traffic data collection. This will further enable appropriate and sustainable decisions to be reached by the authorities concerned on whether or not a new road is required for the prevailing traffic condition, ascertain the timing of the required improvements (such as capacity expansion, structural upgrading or strengthening), etc. To this end, the following obligations are key to the provision and maintenance of the Public Highway Network:

1. Provision of the maximum road benefit to the greater number of people for the minimum expenditure or cost to the economy, by concentrating all construction and maintenance efforts on roads carrying the heavier traffic and maintaining its economic length.

2. Provision of improved roads to areas of administrative and district centers with regard to the resulting economic or social development of the area of population.

3. Strategic responsibility of managing the Public Highway Network with respect to the setting of specifications and standards, and provision of guidelines in the conduct of surveys and studies.

4. Ensure provision of surfaced/bitumen road network connections, that is all weather roads to towns/cities and places of economic activities.

While taking cognisance of the above, the attention is also drawn to the observation that the Southern African Development Community (SADC) region is faced with a tremendous challenge in road development and sustainable maintenance of the existing infrastructure. This scenario is resulting in increased transport operating costs, loss in road investment, etc., which is coupled with declining funds allocations earmarked for road provision and maintenance. It is in view of these occurrences in the region that Botswana should consider it crucial to appropriately collect, analyse and sustainably maintain sufficient traffic data as key input parameters in decision making for development and management of the Public Highway Network.

Gaborone
May 2003

Andrew Nkaro
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Ministry of Works and Transport

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The production of this Guideline has been a joint effort between the Roads Department and the Norwegian Public Roads Administration (NPRA). Messrs. Per Engeset of NPRA and Obusitswe B. Keitheile of Botswana Roads Department jointly compiled this Guideline.

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1 INTRODUCTION

1.1 Background

Botswana with a population of 1.70 million in the year 2001 is projected to have a population of 2.25 million in 2016 and a projected annual traffic growth of 8%. With this scenario, it is expected that the total number of vehicles using the Public Highway Network (PHN) will increase substantially. The resulting vehicle fleet, is expected to be over 300 vehicles per 1,000 persons in the year 2016 from the current level (2002) of approximately 90 per 1,000 persons. This indicates a potential demand for investment in transport infrastructure. Proper utilisation of such huge investments necessitates systematic planning for need-based development. Such need-based developments include determination of the required capacity expansion, provision of additional road infrastructure, improvement of existing roads, prioritisation of different development phases and forecasting of which is possible upon collection of traffic data. This is done in order to eliminate bottlenecks in both international and local inter-urban road transport towards providing an efficient and effective road transport system.

The concept of forecasting the future use of the road network in terms of traffic loading and flow, is generally an accepted approach world-wide. The techniques used have become almost standard in both developing and developed countries. The accuracy of traffic data collection and the subsequent predictions are of paramount importance in the fulfilment of an appropriate planning, design, maintenance monitoring and management of the road network.

In the past, routine collection of traffic data in this country was not considered important for the development and management of the road network. In the early 1970's it was realised that a wide variety of information is required in respect of traffic characteristics for proper maintenance, planning, design, maintenance and management of the national road network. This realisation emanated from concerns raised with regard to the amount of traffic (volume), the composition of the different types of vehicles, their speed, total gross weight, number of axles, axle loads and origin and destination of the journeys. Most of this information result in assessment of progressive or rapid deterioration of the road network towards estimating additional cost required to sustain it.

As a result, attempts are now being made to adopt suitable road traffic methodologies for conducting road traffic surveys, which are both technically and scientifically sound, and operationally convenient to execute under the country's prevailing conditions. This includes the use of both manual and automatic traffic counters, together with computer analysis of the collected traffic data. During the planning, design, construction and maintenance period of the road network, traffic data becomes an essential element in decision-making, and therefore the format and the accuracy of data collection and analysis is critical. It is with this view that this guideline on traffic data collection and analysis has been prepared.

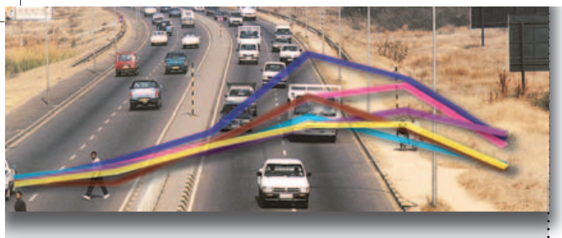

Figure 1.1.1: The main national road network.

1.2 Purpose and Scope of the Guidelines

In order to facilitate the assessment of present and future traffic demands, for the development of need-based infrastructure accurate information and continuous monitoring of traffic by appropriate methods is necessary. Implementing authorities must therefore ensure that sufficient and appropriate data is available to undertake necessary planning, design, construction and maintenance of the country's road network, which is aimed at meeting the prevailing traffic flow, future traffic growth and loading without considerable deterioration in the quality of service.

This guideline has therefore been prepared with the main aim being to provide basic information, concept and principles with respect to traffic data collection and analysis. There are various methods of data collection available and used by different organisations/institutions. This guideline, therefore, is only intended to provide guidance in respect of data collection and analysis, and allows for variation in the methodologies adopted by different users, planners, developers, funding authorities, etc.

The beneficiaries of this guideline are Roads Department, other Ministries/Departments, local authorities, educational institutions, the private sector and individuals.

1.3 Structure of the Guideline

The guideline comprises of nine Chapters and six Appendices.

Chapter 1.0
This chapter gives a broad background on the concept of traffic data collection. The chapter also includes discussion of the purpose and scope of the guideline.

Chapter 2.0
Provides the role and function of the guidelines with respect to traffic data collection and analysis, the types of traffic counts, general specifications and quality assurance of data being collected.

Chapter 3.0
Discuss and give extensive guidance on traffic data collection in Botswana. The chapter starts with an overview of the current practice in Botswana and provides essential approaches required to conduct a proper traffic flow/ volume survey. This Chapter also discusses a process or methodology for selection of counting locations, vehicle classification and configuration, which may vary depending on the resulting use of data.

Chapter 4.0
Provides scenarios for counting characteristics in respect of choice of counting system, traffic volume characteristics and frequency of traffic counts. It also provides guidance regarding data collection and storage.

Chapter 5.0
Considers resources required to undertake the exercise, with respect to staff composition, qualifications and equipment requirements. As the work is to be carried out along motorized national road network, traffic safety on site is key to the resources required.

Chapter 6.0
This chapter deals with issues of safety being paramount to the whole exercise of traffic data collection with particular reference to sighting of counting sites, provision of road signs and markings, etc.

Chapter 7.0
This is the core chapter in this guideline, as it provides guidance on vehicle counting, with particular reference to factors affecting vehicle counting, accuracy, duration of counts, counting procedures, typical counts conversions and reference curves.

Chapter 8.0
This chapter presents typical counts conversions and reference curves. It also outlines layout of the analysis, data entry, analysis, and reporting.

Chapter 9.0
This chapter outlines the recommended layout of traffic data analysis, data entry and its presentation, however, the recommeded methods are not exhaustive.

2 TRAFFIC DATA COLLECTION

Project identification or inception.

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Project appraisal and feasibility.

↓

Project screening and planning.

↓

Project Design.

↓

Project Implementation.

↓

Operation, Monitoring and Maintenance.

↓

Traffic flow data is important in planning of a particular section of the road.

2.1 Role and Function

Traffic Data Collection and projections thereof of traffic volumes are basic requirements for planning of road development and management schemes. Traffic Data forms an integral part in the science of descriptive national economics and such knowledge is essential in drawing up a rational transport policy for movement of passengers and goods by both government and the private sectors.

This Guideline considers the fact that traffic flow data is important in planning of a particular section of the road network and for its subsequent maintenance. Traffic flow pattern appears to be random in distribution, as it reflects people's motivation in terms of different composition of vehicles on different types of roads under varying environmental conditions.
It follows then that data being collected is a methodological statistics, because traffic flow pattern follows a random distribution. Despite such complexities, it does follow fairly and clearly defined patterns that are possible to classify and analyse. Thus, traffic data collection and analysis follows varying trends and plays an important role in the evaluation and management of road network schemes.

While taking cognisance of the above, traffic flow data is needed for different purposes by different Ministries and/or Organisations in Botswana. The major areas for which this data is required are:

- Planning prioritisation and project initiation.
- Project design.
- Planning maintenance.
- National Transport Statistics.
- Road Safety Measures.
- Traffic Control.

Some of the key areas in which traffic flow data is needed for development and management of the road network include:

a) Determination of a programme of road widening needs and general improvement or strengthening of existing road through a programme of reconstruction and construction of a new roads;

b) To check the efficiency of the road network by comparing current traffic volume with the level of service or the calculated capacity;

c) To establish the relationship between traffic volume, number of accidents and causes thereof, as well as determination of the probable occurrences;

d) To plan prioritisation of roads improvement schemes;

e) To assess economic benefits arising from roads improvements;

f) Investigation of various capacity and design problems for both roads and bridges and parking facilities.

g) Design and improvement of new/existing junctions;

h) Assistance in planning new developments such as roads in a new town, subdivisions, land use, which generally includes shopping centres, hotels, commercial and industrial complexes, service stations and other traffic generators activities;

i) Determination of warrants or the need for implementation of traffic improvement and traffic control measures, such as synchronised/coordinated traffic signals, stop signs, one way roads, no entry, etc;

j) To study future traffic trends and assisting in predicting traffic flows in the future for a given period;

k) To classify roads on their functional basis.

In addition to the above the following are typical specific needs:

a) Assessment of pavement performance through traffic surveys and Period monitoring of selected sections;

b) Ascertaining appropriate/optimal timings for maintenance interventions and rehabilitation needs of various roads countrywide;

c) Establish economic and social implications of design and feasibility studies of all development projects countrywide;

d) Establish the use of the road network by vehicles of different categories, traffic distribution, etc.

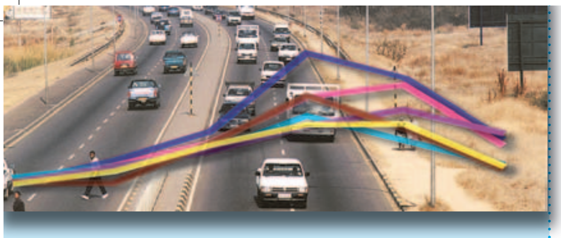
2.2 Types of Traffic Counts

It is essential to know the magnitude of traffic data required or to be collected, which will then determine its quality and type of vehicle classification to be adopted. Traffic counting falls in two main categories, namely; manual counts and automatic counts. There is no distinct difference between the two methods however, the economic use or selection of an appropriate method of traffic counting is a function of the level of traffic flow and the required data quality. This difference can be deduced from the discussions of the respective methods below, and in the subsequent chapters.

Manual traffic counting in progress.

2.2.1 Manual Counts

The most common method of collecting traffic flow data is the manual method, which consist of assigning a person to record traffic as it passes. This method of data collection can be expensive in terms of manpower, but it is nonetheless necessary in most cases where vehicles are to be classified with a number of movements recorded separately, such as at intersections.



At intersection sites, the traffic on each arm should be counted and recorded separately for each movement. It is of paramount importance that traffic on roads with more than one lane are counted and classified by direction of traffic flow.

About 64 permanent manual traffic-counting stations have been established countrywide by Roads Department.

Permanent traffic-counting teams are normally set up to carry out the counting at the various locations throughout the road network at set interval. The duration of the count is determined prior to commencement of traffic counting and it is dictated by the end use of data. The teams are managed and supervised by the technical staff to ensure efficient and proper collection of data. (Survey Forms used for manual traffic-counting, is given in *Appendix A1, A2* and *A3.*

2.2.2 Automatic Counts

The detection of vehicular presence and road occupancies has historically been performed primarily on or near the surface of the road. The exploitation of new electromagnetic spectra and wireless communication media in recent year, has allowed traffic detection to occur in a non-intrusive fashion, at locations above or to the side of the roadway. Pavement-based traffic detection currently relatively inexpensive, will be met with fierce competition in the coming years from detectors that are liberated from the road surface.

The most commonly used detector types are:

i) Pneumatic tubes.

These are tubes placed on the top of road surfaces at locations where traffic counting is required. As vehicles pass over the tube, the resulting compression sends a burst of air to an air switch, which can be installed in any type of traffic counting devices. Air switches can provide accurate axle counts even when compressions occur more than 30 m from the traffic counter. Although the life of the pneumatic tubes is traffic dependant as they directly drive over it, it is used worldwide for speed measurement and vehicle classification for any level of traffic. Care should be exercised in placing and operating the system, to ensure its efficient operation and minimise any potential error in the data.

ii) Inductive loops.

Inductive loop detector consists of embedded turned wire from which it gets its name. It includes an oscillator, and a cable, which allows signals to pass from the loop to the traffic counting device. The counting device is activated by the change in the magnetic field when a vehicle passes over the loop. Inductive loops are cheap, almost maintenance-free and are currently the most widely used equipment for vehicle counting and detection. Single loops are incapable of measuring vehicular speed and the length of a vehicle. This requires the use of a pair of loops to estimate speed by analysing the time it takes a vehicle to pass through the loops installed in series. An inductive loop can also, to a certain degree, be used to detect the chassis heights and estimate the number of axles.

Security for counting equipment is very essential.

By using the inductive loops, the length of the vehicle is therefore derived from the time taken by the vehicle to drive from the first to the second

loop (driving time) and the time during which the vehicle was over the first and the second loop (cover time). The resulting length is called the electrical length, and is in general less than the actual length of the passing vehicle. This is caused by the built in detector threshold, the road surface material, the feeder length, the distance between the bottom of the vehicle and the loop, but also, to a large extent, the synthetic materials used in modern cars. The system could be used for any level of traffic.

iii) Weigh-in-Motion Sensor types.
A variety of traffic sensors and loops are used world-wide to count, weigh and classify vehicles while in motion, and these are collectively known as Weigh In Motion (WIM) sensor systems. Whereas sensor pads can be used on their own traffic speed and axle weighing equipment, they are trigged by "leading" inductive loops placed before them on the roadbed. This scenario is adopted where axles, speed and statistical data are required. Some notable traffic sensors are:

- **Bending Plates** which contains strain gauges that weigh the axles of passing vehicles. Continuous electric signals are sent to the strain gauges, and these signals are altered as the plates are deflected by dynamic vehicular weight and measure the axle of the passing vehicles.

- **Capacitive Strip** is a thin and long extruded metal used to detect passing axles. The force of vertical pressure applied to this strip by a wheel alters its capacitance, which can be converted to a wheel-weight measure when related to the speed of the vehicle. Capacitive strips can be used for both statistical data and axle configuration.

- **Capacitive Mat** functions in a similar manner as the capacitive strip but it is designed to be mobile and used on a temporary basis only.

- **Piezo-electric Cable** is a sensing strip of a metallic cable that responds to vertical loading from vehicle wheels passing over it by producing a corresponding voltage. The cable is very good for speed measurement and axle-space registration, and is relatively cheap and maintenance free like a inductive loop if installed correctly.

iv) Micro-millimetre wave Radar detectors.
Radar detectors actively emits radio active signals at frequencies ranging from the ultra-high frequencies (UHF) of 100 MHz, to 100 GHz, and can register vehicular presence and speed depending upon signals returned upon reflection from the vehicle. They are also used to determine vehicular volumes and classifications in both traffic directions.

Radar detectors are very little susceptible to adverse weather conditions, and can operate day and night. However, they require comparatively high levels of computing power to analyse the quality of signals.

v) Video Camera.
Video image processing system utilise machine vision technology to detect vehicles and capture details about individual vehicles when necessary. A video processing system usually monitors multiple lanes simulta-

Automatic counting station secured and operated by solar power.

Typical installation of inductive loops.

A weigh –in-motion speed and axle detection pad.

Weigh-in-Motion along Trans-Kgalagadi Highway.

neously, and therefore it requires high level of computing power. Typically, the operator can interactively set the desired traffic detection points anywhere within the system's view area.

Algorithms are used to extract data required for the detection of the raw data feeds. Due to the complexity of the images, it is not recommended that they should be processed outdoors as this can give poor results. The system is useful for traffic counting and give a +/- 3% tolerance, and is not appropriate for vehicular speed and their classification.

2.3 General Specifications

General specification provide guidance for the allocation and distribution of traffic counting points along the national road network. This is done in order to maintain consistency and attainment of appropriate comparisons of data between counting stations.

From traffic counts observations at different locations in the country, it has been noticed that manual counts may be prone to increased human error when the number of enumerators are increased commensurate with increasing traffic flow.

In the context of this guideline, temporary automatic counting can be to a minimum of seven-day continuous counts four times a year. At these stations both the loops and the roadside cabinet have to be installed. The equipment for automatic counting can therefore be moved around to the various temporary stations as required. Some of the temporary stations can later be converted to permanent stations, as required, when the traffic flow increases.

Number of Vehicles (paved)	Number of Vehicles (unpaved)	Automatic Counts	Manual Counts
> 2000		Required at permanent stations continuously throughout the year.	
1000 - 2000		For specific period to be adopted (temporary automatic counting).	Could be used when appropriate, that is depending on the level of traffic flow.
< 1000			Counted at intervals for seven consecutive days, 16 hours per day, four times a year.
	> 50		Counts for seven consecutive days for 16 hours once a year or as deemed appropriate for the end use of data.
	20 - 50		Counts for seven consecutive days, 16 hours a day, once every year or as deemed appropriate.
	< 20		No traffic counts should be carried out unless required for special reasons.

Table 2.3.1: Summary of recommended traffic flow counting levels.

Number referencing of automatic counting stations.

Proper maintenance of counting stations ensures minimum disturbance to the system and reduces potential damage and vandalism.

A national dual carriageway road with a continuous traffic flow in an urban environment.

Classification of vehicles by type reflects the mix in the traffic stream passing the counting point.

3 TRAFFIC DATA COLLECTION, PRACTISES IN BOTSWANA

1.1 General

The primary source of traffic data collection in Botswana is through establishment of regular manual traffic counting programmes and spontaneous automatic counters along the public highway network. Presently (2002), 64 permanent manual traffic count stations are located country-wide managed by Roads Department. In addition, there are other stations established for special traffic counts such as ad-hoc (short-term) counts or special counts, which are mainly conducted on roads without permanent stations. Origin – Destinations survey is a special way of carrying out traffic counts/survey, whereby the data collected relates to the use of the road by vehicle category.

A typical traffic counting station.

The various types and methods used to collect traffic data not only provide a good and valuable coverage of the required traffic information for decision making and planning of both development and maintenance of the national road network. On this basis, all local authorities, institutions/organisations, etc., are urged to use this Guideline as a tool in the implementation of a traffic counting system to enable creation of a national data base at their respective levels of operation for all classes of roads including tertiary roads, access roads, town/city roads, village roads, and many others not accounted for in this Guideline for proper management of the road infrastructure.

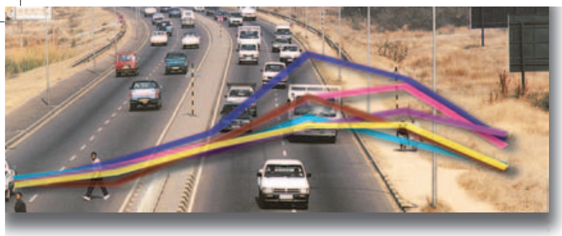
3.2 Selection of Counting Sites

As stated earlier, the typical traffic counting system used by Roads Department composed of 64 permanent manual traffic counting stations and additional various special counting stations.

A typical straight road.

A specific location for counting site (permanent or temporary) must be determined on site. Where automatic counting system is to be used, the exact locations of loops should be decided while taking cognisance of the potential use of data collected. The following should be kept in mind before deciding on the counting site:

- The road section should have uniform geometric characteristics along the road length and be away from junctions;
- Location should be on a horizontal (flat) and geometrically straight road section;
- Section of the road to have an uninterrupted traffic flow;
- Sections where telephone lines or radio (mobile) are easily accessible or can be installed, if possible;
- Section to have very little pedestrian or animal traffic;
- Section to meet safety requirements.



In areas where trunk roads are in the vicinity of major city limits or town boundaries (such as Gaborone, Francistown and Lobatse), the locations of counting sites using loops should be looked into in more detail. Inductive loops at traffic signals may also be used for traffic counting in major cities and towns.

To ensure that adequate attention is given to sections of roads constituting a specific traffic flow, roads should be divided into uniform sections according to traffic characteristics.

3.3 Vehicle Classification and Configuration

It is important to know the most damaging categories of vehicles at the earliest stage of the design.

Although there are various classification approaches available to various institutions/organisations or end users of this Guideline, the responsible organisation/institution may use whichever method is deemed appropriate and applicable for the purpose at hand, depending on the quality of data required.

Manual Count classification

Manual traffic flow count is categorised by a visual assessment of the vehicle size and configuration of axles. The current manual traffic flow data collection system in Botswana classifies vehicles into nine categories as follows:

- Passenger Cars .... (1M)
- Pick up or Van less than 1.5 tons .... (2M)
- Trucks, more than 1.5 and less than 5 tons .... (3M)
- Light Lorries, more than 5 and less than 10 tons .... (4M)
- Medium Lorries, more than 10 and less than 20 tons .... (5M)
- Heavy Lorries, more than 20 tons .... (6M)
- Heavy Busses .... (7M)
- Mini Busses .... (8M)
- Agriculture Tractors .... (9M)

Load distribution over the various vehicle axle configurations determines the vertical load on the road.

Trucks-	two axles, 4 x 4 vehicles of 1.5 tonnes but less than 5 tonnes.
Light Lorries-	commercial vehicles of two axles. These are vehicles with 5 tonnes but less than 10 tonnes.
Medium Lorries-	vehicles with 3 or 4 axles and having weight of more than 10 tons but less than 20 tons.
Heavy Lorries -	all lorries with 5 axles or more and weight more than 20 tons.

Heavy vehicle category	Definitions
Buses	Seating capacity of 40, or more
Medium Goods vehicle MGV	- 2 axles, incl. steering axle, and - 3 tonnes empty weigh, or more
Heavy Goods Vehicle HGV	- 3 axles, incl. steering axle and - 3 tonnes empty weigh, or more

Table 3.3.1: Traffic count classification for axle load analysis.

Whereas the above are the vehicle categories in use, it is important to note that traffic counting and classification is a dynamic process and its project based. Table 3.3.1 above is a typical classification of heavy vehicles by their configuration for purposes of axle load analysis. In this context, information being collected should ensure multiple uses of data collected either manually or by automatic system.

Automatic Traffic Counts

A fully equipped Automatic Traffic Counters with inductive loops and WIM-sensors (weigh pad) has a potential of classifying traffic as required by means of the following classification parameters:

- Number of axles.
- Weight of each axle.
- Axle spacing.
- Speed.
- Vehicle length.
- Chassis height.

Where only inductive loops are used the parameters that can be registered are:

- Speed.
- Vehicle length.
- To a certain degree Chassis height.
- The number of axles can be estimated.

As a result, it is appropriate to use automatic traffic counters with either:

- Inductive loops only where traffic flow data is required; or
- Inductive loops and WIM sensors where both traffic flow data and axle or speed measurements are required.

Notwithstanding the above, where only inductive loops are used it is possible to count 5 classes using the following axle spacing classification:

1L Light vehicles, Cars, Taxis, Vans and Pick-Ups ....(length 0 - 5.5 m)

2L Unarticulated trucks, 2 - 3 axle Trucks, Buses ....(length 5.6 - 7.5 m)

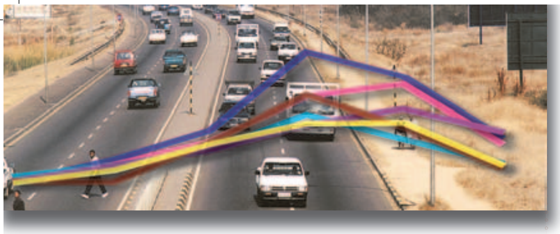
3L Unarticulated bus, Buses and Trucks ....(length 7.6-12.4 m)

4L Heavy trucks and very long Buses .... (length 12.5 - 15.9 m)

5L Heavy trucks ....(length 16.0 – 22.0 m)

Vehicle classification can be determined by the number of axles and the gross vehicle mass.

Ensure that traffic data collected has a multiple use and captures relevant classes or types of vehicles for the intended purpose.



With inductive loops and WIM censors installed it is possible to count 7 classes as follows:

1W Car, Taxi and Vans.........................(2 axle, length 0-5.5 m)
2W 4W-drive Pick-Ups........................(same as 1W, but with higher chassis)
3W 2-axle Trucks and Buses................(length 5.6 – 7.5 m, weight - 2 tons)
4W 3-axle Trucks and Buses...............(length 5.6 - 7 m, weight 2 - 20? ton)
5W 2-3 -axle Buses and Trucks ....(length 7.6 - 12.4 m)
6W 4-5-axle Trucks..............................(length from 12.5 m)
7W 6 or more axle Trucks....................(length from 16.0 m)

A typical bus with 2 axles.

Where counts have been done with both WIM and inductive loops it is often difficult to specify the classification of aggregated data. A better solution is to store the following measured data for each vehicle type:

- Date and time.
- Speed.
- Total length .
- All axle spacing.
- All axle weights.

When data has been stored for each vehicle, various options can be selected and the computer can be programed to perform various calculations as may be required.

Cars, vans and pick-ups constitute high proportion of traffic in the country.

With the use of inductive loops in each lane it is possible to measure the vehicle speed very accurately. Most counting equipments have speed registration which then group vehicles into speed categories, again these can be used to group the different vehicles by their axle spacing. Some counting equipment has the facilities to register the average speed and variation of the speed.

For each direction the following vehicle speed data should be collected hourly:

- Average speed of all vehicles
- Speed variation of all vehicles
- 85 % faster than
- 15 % faster than
- Vehicles > 60 km/h
- Vehicles > 80 km/h
- Vehicles > 100 km/h
- Vehicles > 120 km/h
- Vehicles > 140 km/h
- Number of vehicles < 2 sec behind vehicles ahead
- Average speed length for group 1L
- Average speed length for group 2L
- Average speed length for group 3L
- Average speed length for group 4L
- Average speed length for group 5L

A speed, axle and traffic flow data collection station with a lockable counting equipment box.

In recent years substantial efforts have been made by various traffic authorities all over the world to develop/use suitable Weigh-in-Motion (WIM) equipment, in some cases these efforts have not been fully successful.

History has shown that the use of automated systems by Roads Department has not been too successful for the collection of traffic data using both WIM and statistical traffic data. The main problems are associated with the

RIGID - CHASSIS COMMERCIAL VEHICLES		ARTICULATED COMMERCIAL VEHICLES	
11	Single tyres on front and rear axles	1.1 - 1	Single tyres both axles of tractor Single tyres axle of trailer
12	Single tyres on front axle Twin tyres on rear axle	1.1 - 11	Single tyres on both axles of tractor Single tyres on both axles of trailer
1.11	Single tyres on front axle Twin tyres on rear axles Two rear axles	1.1 - 22	Single tyres on both axles of tractor Twin tyres on both axles of trailer
1.22	Single tyres on front axle Twin tyres on rear pair of axles Two rear axles	1.2 - 1	Single tyres on front axle of tractor Twin tyres on rear axle of tractor Single tyres on axle of trailer
11.11	Single tyres on front pair of axles Single tyres on rear pair of axles	1.2 - 11	Single tyres on front axle of tractor Twin tyres on rear axle of tractor Single tyres on both axleS of trailer
11.2	Single tyres on front pair of axles Twin tyres on rear axle	1.2 - 2	Single tyres on front axle of tractor Twin tyres on rear axle of tractor Twin tyres on axle of trailer
11.22	Single tyres on front pair axles Twin tyres on rear pair of axles	1.2 - 22	Single tyres on front axle of tractor Twin tyres on rear axle of tractor Twin tyres on both axle of trailer
1.2 + 1.1	TRAILERS Single tyres on both axles	1.22 - 2	Single tyres on front axle of tractor Twin tyres on both rear axles of tractor Twin tyres on rear axleS of trailer
1.2 + 1.2	Single tyres on front axle Twin tyres on rear axle	1.22 - 22	Single tyres on front axle of tractor Twin tyres on both rear axles of tractor Twin tyres on both rear axles of trailer
1.2 + 2.2	Twin tyres on both axles	1.22 - 111 1.22 - 222	Single tyres on front axle of tractor Twin tyres on both rear axles of tractor Single/twin tyres on axles of tractor

Figure 3.3.1: Typical axles configurations in the country.

frequent breakdown of the equipment. Firstly, this has been due to lack of adequate or sustainable maintenance. In the future, when purchasing new traffic counting equipment, the maintenance of the equipment should be included as part of the supply agreement. This includes periodic, emergency and routine maintenance activities.

Collection of axle loads data could therefore be dealt with as a separate task using mobile weighbridges, if the weight measurements are separated from the traffic flow data collection.

A pilot project in 1997/98 involving both Truvelo and Micros equipment was carried out in Botswana by Roads Department. In brief, the conclusion were:

- *Both systems can work satisfactorily only under supervision of highly specialised personnel. Maintenance and calibration should be done at regular intervals.*
- *Moderate changes in processing software, calibration algorithms and system refinement should always be a continuous process as the technology develops.*
- *It is virtually impossible to operate the system without close interaction and assistance of the manufacturers.*

From this pilot project the Mikros System equipment was found to be having less operational constraints, and there by being extensively used in Botswana.

Table 3.3.2: WIM pilot project in Botswana.

Lack of proper maintenance can lead to some stations being rendered un-operational and loss of important traffic data.

A damaged road surface exposing induction cables is prone to damage.

4 COUNTING CHARACTERISTICS

4.1 Traffic Flow

4.1.1 Frequency of Traffic Counts

In order to predict traffic flow volumes that can be expected on the road network during specific periods, cognisance should be taken of the fact that traffic volumes changes considerably at each point in time. There are three cyclical variations that are of particular interest:

- **Hourly pattern:** The way traffic flow characteristics varies through out the day and night;
- **Daily Pattern:** The day-to-day variation throughout the week; and
- **Monthly and yearly Pattern:** The season-to-season variation throughout the year.

When analysing the traffic one must also be aware of the directional distribution of traffic and the manner in which its composition varies.

Hourly patterns

Typical hourly patterns of traffic flow, particularly in urban areas, generally show a number of distinguishable peaks. Peak in the morning followed by a lean flow until another peak in the middle of the afternoon, after which there may be a new peak in the late evening. The peak in the morning is often more sharp by reaching the peak over a short duration and immediately dropping to its lowest point. The afternoon peak on the other hand is characterised by a generally wider peak. The peak is reached and dispersed over a longer period than the morning peak. However, in urban satellite towns, the morning peak may be too early and evening peak may be too late in comparison to the principal towns without significant midday peak.

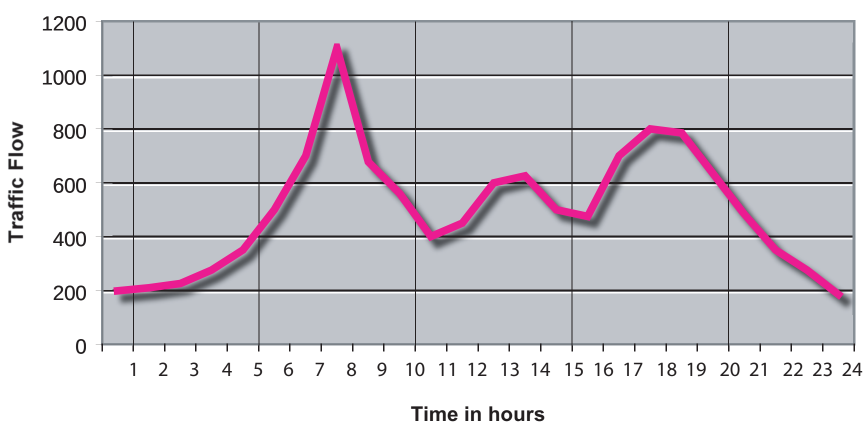


Figure 4.1.1: Traffic peak flow variation.

Experience from many countries shows that although traffic volumes may grow over time, the relative variations of traffic at the various hours of the day of a month are often quite consistent year after year.

An earth/sand road in a rural area.

Daily patterns

The traffic volume generally varies throughout the week. The traffic during the working days (Monday to Friday) may not vary substantially, but the traffic volume during the weekend is likely to differ from the working days on different type of roads and in different directions. In Botswana many of the urban population goes to the rural areas during the weekends, hence a high variation of traffic on the urban – rural connector roads during weekdays and weekends.

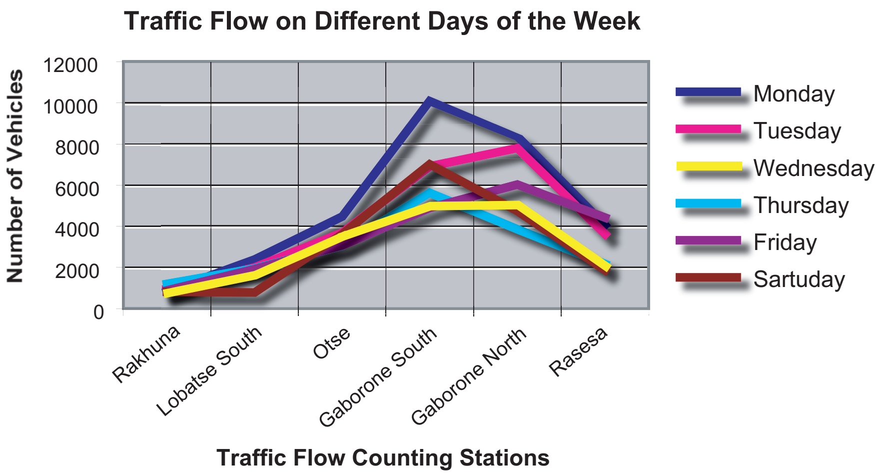


Figure 4.1.2: Daily traffic flow variations.

The pattern from Monday to Friday is often relatively consistent, a part from Monday morning and Friday afternoon traffic flow. The pattern during the weekend may vary considerably. The pattern also varies from Saturdays to Sundays. The pattern during the weekends is also likely to show more seasonal variation than during the working days.

Monthly and yearly patterns

The monthly and yearly pattern normally reflects the seasonal variation of traffic flow. The pattern may vary for passenger cars and vehicle transporting goods. In Botswana, variation between traffic flow during the wet season and during the dry season is insignificant.

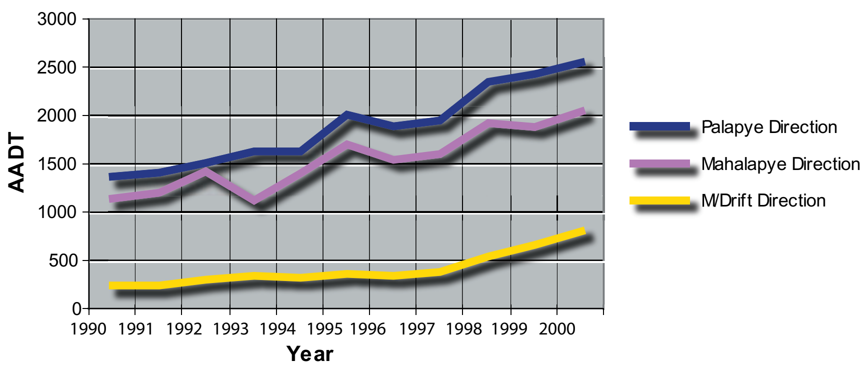


Figure 4.1.3 : Annual traffic flow variations by direction.

Knowledge of how traffic flows varies for different vehicle classes may be very useful when designing programmes for axle load control, design of roads improvement upgrading schemes and setting maintenance programmes and priorities. Although Botswana is not known to have significant seasonal variation in traffic flow, such occurrences should be

considered so as to adequately account for them through application of appropriate conversion factors.

A well maintained gravel secondary road to meet traffic demand.

Monitoring traffic growth variations

The number of motor vehicles licensed in Botswana has shown an increase in traffic flow steadily over the years. In the 1980's the annual traffic growth was 11-12 % and it was highest on paved roads, while in 2000 the growth rate was in the order of 7 – 8%.

	Palapye Direction	Mahalapye Direction	M/Drift Direction	Total
1990	19	20	21	**60**
1991	3	6	-4	**5**
1992	7	17	23	**47**
1993	6	-21	14	**-1**
1994	-1	25	-3	**21**
1995	24	22	10	**56**
1996	-7	-10	-3	**-20**
1997	4	4	10	**18**
1998	21	20	39	**80**
1999	3	-2	21	**22**
2000	4	8	18	**30**

Table 4.1.1 : Percentage traffic flow fluctuations by direction at station N9 .

Upgrading of a road is a function of both traffic demand(growth) and prevailing human population to be served.

Although the annual traffic growth may have been less in the 1990's than in the 1980's, the present national growth rate of 8% is quite high and needs to be monitored to ensure timely provision or improvement of the national road network. It is therefore critical to monitor growth rates on newly paved roads on monthly or quarterly basis immediately after opening to traffic to guard against rapid growth due to presence of the surfaced road.

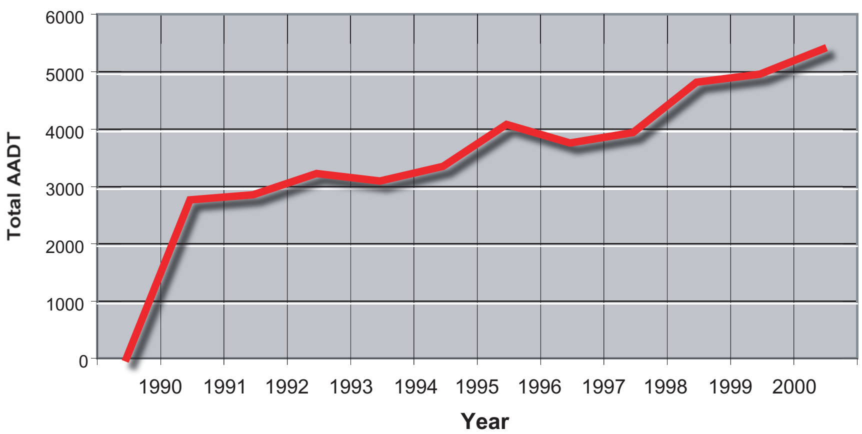


Figure 4.1.4: Typical annual traffic growth variations.

When a gravel road is upgraded to paved standard, the traffic pattern on both the road concerned and on the network changes due to the improved state of the road. Some of the old paved roads may have a reduced traffic flow and also an overall change in the composition of vehicles using the

road. This is often a result of traffic redistribution and routes re-prioritisation by different road users.

4.1.2 Data Acquisition

Most counting systems are used for daily, weekly or monthly administrative counting periods, at an interval of one hour or as required by the end user. These administrative counts are carried out continuously, unless it is moved to a new counting location. The traffic data at the end of a counting period is remotely brought to a central point for processing and subsequent storage. Where communication lines are not provided to retrieve data remotely a laptop computer is used to retrieve data from site then down loaded into a PC for subsequent analysis.

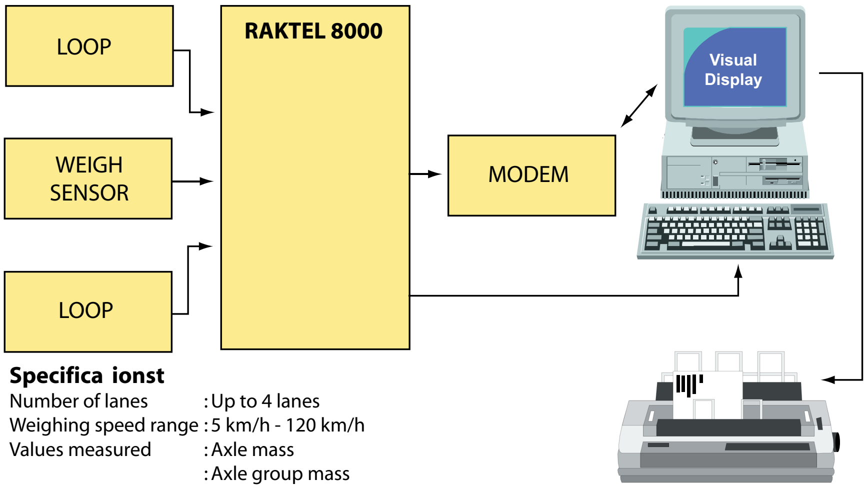


Figure 4.1.5: A typical configuration of an automatic traffic counting network.

In certain situations more detailed information of traffic flow may be needed. In such cases the counting equipment is set for shorter counting intervals generally between 5 to 15 minutes.

It is important that the rolled-out counting data (data from numerous counts and dating back some years) can be identified unambiguously from its storage. Part of this protection should be found in the processing software and the rolling-out procedure should explicitly be stated in the system's operating manual.

It is recommended that the rolling-out program uses the number of the census site and the date of the start of the administrative counting period, to create a unique file name, which allows files to be identified at ease. Therefore it is recommended that the following information is stored:

- Name of Authority/Organisation.
- Version number of rolling-out software.
- Version number of counting software.
- Counter identification number.
- Location code.
- Location name.
- Lane identification.
- Counter configuration

While traffic counting mainly aims at motorised traffic, animal traffic are of importance at design stages for determination of appropriate and safe crossing points.

It is desirable that the rolling-out software creates a file in a file system that permits unlimited numbers of new parameters to be added on.

The data from the manual counting stations can be retained in the manual forms or be transformed to the data file system where computers are available for further processing and proper storage. A special computer program will have to be developed for this purpose. Where off the shelve software are available such software should be used instead of developing new programs.

Institutions engaged in traffic data collection for development and maintenance of the road network should used readily available systems or programs.

From the automatic traffic counters data should be transferred from the counting equipment to a PC or to a data module in the form developed to suit the format available within the institution/organisation. With the proper system in place, then the data can automatically be converted to the file system on a PC as specified by the relevant authority.

Data from the automatic traffic counting system should be compiled separately for traffic flow directions.

It is recommended that the same file system both for manual and automatic counting data should be used to ensure attainment of the required comparison of information or results.

The data should be stored as files in the specified file system that has a file name in order to permit easy recognition of data. For security reasons copies of files should be stored as zipped files, but critically, analysed data should be stored with a password in a secured place in the computer system. Further, it is convenient to keep the back up of those files preferably in CD-ROM.

4.1.3 Routine Counts

These are normal or scheduled counts conducted at regular intervals for a set purpose, such as monitoring of traffic flow patterns for determination of historical trend or determination of applicable factors (e.g. growth or conversion factors).

4.1.4 Ad-Hoc or Unscheduled Counts

Ad-hoc counts may be conducted along some roads, which carry low traffic intensities. However, over the years as it becomes evident that traffic on these roads has increased, scheduled traffic counting stations may be established.

4.1.5 Origin – Destination Surveys

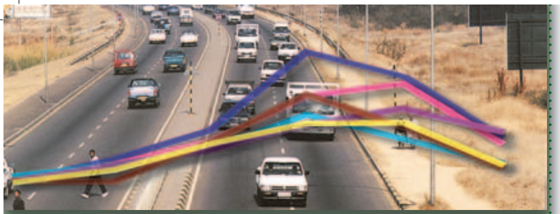
In an Origin and Destination (O-D) survey, interviews of vehicle users by enumerators are conducted. The approach to such O-D survey depends on the scope and quality of information’s required. Some of the methods available include roadside interviews, postcard, tag and disc, vehicle registration number etc.

Prior to commencement of O-D survey, the enumerators shall be briefed about the task and if necessary, a familiarisation course should be undertaken before commencement of such surveys. The survey shall be carried

out at ideal locations having good visibility without having prominent horizontal and vertical curves. Further, selected spots shall preferably have adequate safety strip to park the vehicles away from the traffic lane. Depending on the requirement the enumerators shall be instructed to collect information on the following:

- Time of Interview.
- Type and weight of commodity being carried.
- Type of vehicles.
- Number of passengers in the vehicle.
- Origin of the journey.
- Immediate destination.
- Final destination.
- Start time of journey.
- Expected end time of journey.
- Frequency of trip.
- Other relevant information’s.

The origin and destination points are the starting and final destination zones of a trip, which may be in different zones as well as in the same zone.



5 RESOURCES REQUIRED FOR COLLECTION OF TRAFFIC DATA

5.1 General

Assessment of available resources prior to commencement of any activity is critical to any assignment at hand. For traffic data collection, it is important that proper assessment of the extent or scope of the envisaged counting (quality level of data required) is undertaken. This is aimed at ensuring that the planned and organised exercise is achieved at optimal cost and with the expected accuracy. The exact number of persons and equipment to undertake a specific traffic counting assignment is dependent, among others, on:

- The location of the station.
- The quality of data to be collected.
- The level of traffic flow.
- The nature of the road section and traffic flow characteristics within which the station falls.
- Traffic composition.

5.2 Staff Composition and Qualification

More often staffing for conducting traffic counts is not deemed to be critical to the quality of data being collected, as the exercise is regarded just as counting of vehicular traffic and groups as they pass a specific point on the road. While taking cognisance of this concept, the selection criteria contained herein is not prescriptive as it only recommended that in the case of Botswana, field enumerators appointed for traffic surveys should have at least a minimum of General Certificate of Secondary Education (GCSE) to enable them to be continuously trained in this field. All enumerators upon employment should undergo a training programme before being assigned to work alone in the field. This training is aimed at familiarising new employees with vehicle classification/configuration processes, use of different automatic counting equipment as stated early (where available), refer to *Guideline No. 4,* Axle Load Surveys any other activity associated with traffic data collection and analysis.

While the majority of the enumerators may be based in the field collecting raw data, some should be stationed at office to transform the raw data into analysis forms, either for subsequent storage or transfer into the computer system to further analysis.

The office staff should have a working experience as field enumerators to ensure full understanding of the raw data they are expected to transform into the analysis forms. They should as well have at least a GCSE Certificate. The Office Enumerators should undergo a thorough Computer

software training programme, such as data processing, spreadsheets, appropriate traffic data analysis system(s) available and any other related systems for the exigency of the service.

Due to the changes in the types of the vehicle fleet using the road network and the varying quality and use of traffic data, traffic enumerators should have specialised courses arranged at set periods or intervals. The courses should include, among others, the importance of traffic data collection and its use, employment regulations, first aid programmes, and any other programme deemed to be relevant for the achievement of the service or assignment. However, specialised courses should be tailor made for office enumerators in computing and the management of stored data.

A security fence for traffic counting equipment.

5.3 Equipment Requirement

5.3.1 Automatic Traffic Counting Equipment

Although a detailed discussion of the various types of automatic traffic counter equipment and systems was dealt with in *Chapter 2.0* the main aim of this part is to sight typical equipment required for traffic data collection. In essence, typical automatic traffic data collection equipment consists of a detector to detect vehicles and a counter to record the information, some of which are shown below.

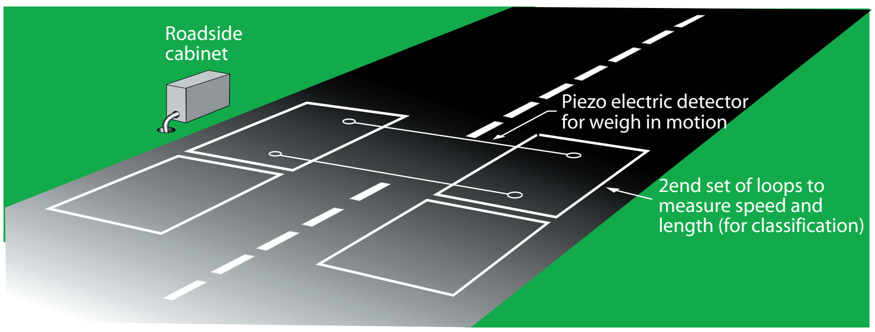


Figure 5.3.1: Typical layout of traffic loops on the road surface.

Counting equipment fixed to a traffic signpost.

Figure 5.3.2: Typical equipment for traffic data collection.

A roadside box or cabinet for storage of a traffic counter.

6 TRAFFIC AND SITE SAFETY

6.1 General

Traffic safety during the conduct of traffic surveys is mandatory and is the responsibility of the institution or body undertaking the surveys. The Road Traffic Act Cap 69:01 places a statutory responsibility in ensuring that appropriate safety measures are in place before a survey can be conducted on a road.

6.2 Site Safety

The location of the counting sites should be chosen with full consideration to traffic safety both for installation, maintenance and use of the site. Whenever manual traffic surveys are in progress, proper signals should be in place for safety of enumerators. The site should be inspected for safe use by supervisor who should also ensure that no sign is removed from site until the survey is completed.

6.3 Site Markings

Both the automatic and manual counting sites should have an unambiguously identification number. The counting site number is linked to the existing Road Reference System. It is recommended that the counter storage boxes be marked with an identity number plate.

7 TRAFFIC COUNTING PROCEDURES

7.1 General

The result of traffic counting is subject to sampling error and observational uncertainty. Sampling error in traffic counting is error emanating from collected traffic data while observational error relates to vehicle classification by vehicle types resulting in some vehicles being wrongly classified. In this context, vehicle classification cannot be defined without ambiguity and therefore is a subject of enumerators' interpretation of the passing traffic stream. To minimise the error, statistical methods are more preferable to use for analysis to smooth out sampling and observational errors.

Automatic counters mainly use the distance between axles to classify vehicles. In situations where vehicles of different make have similar axle spacing, the automatic counter cannot ascertain that these are two different vehicles. The resulting scenario is that either the system rejects all vehicles it cannot classify or misclassifies them, thus resulting in classification error. Where there is a significant proportion of unclassified vehicles the level of error is deemed to be very high and the results should not be used for any economic decision making purpose.

A typical situation is that of Toyota 4 x 4 Hilux and Toyota Hi Ace combi, have the same axle spacing. It is therefore advisable that traffic data from an automatic counter is cross checked by taking a manual count to enable easy checking and comparison of the error margin.

A Toyota 4x4 Hilux has similar axle spacing as a Toyota Hi-Ace combi/minibus.

A Toyota Hi-Ace combi/minibus.

7.2 Factors Affecting Vehicle Counting

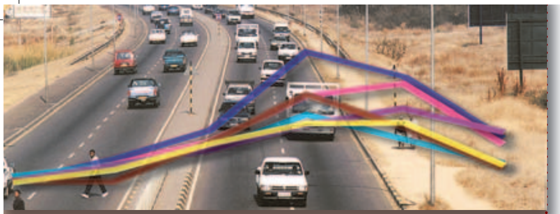
There are many factors that affect traffic counting and the most common includes:

- Weather conditions.
- Purpose of the traffic counting.
- Method of traffic counting.
- Location of the counting sites.
- Traffic flow level.
- Road type.
- Traffic composition.

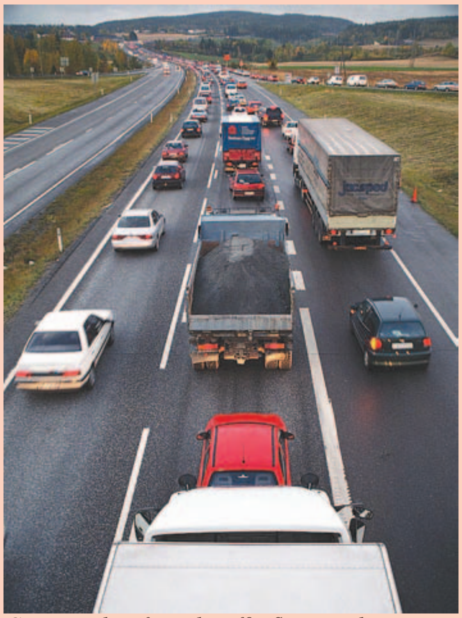
Weather Conditions
Traffic counting during high and low weather conditions have serious effect on the enumerators through an interrupted counting process resulting in severe data errors.

Purpose of Traffic Counting
Understanding the purpose for which traffic is being counted enables collection of appropriate quality data, the number of vehicle classes and determination of the duration of the count. For major projects, good quality data is required for a pre-determined number of vehicle classes at specific intervals over at least five working days for 12 to 16 hours per day, excluding public holidays or special occasions, such as independence day. Any other exercise that is not of major significance should require less counting duration.

Location of traffic counting sites is a function of the end use of data being collected.



A traffic counting station in a rural area.



Congested or forced traffic flow condition.

Normal continuous traffic flow condition.

Method of Traffic Counting

The method of traffic counting has a bearing on the quality of data obtained. Manual counting of vehicles passing a point at specific intervals (15 minutes, 30 minutes, 45 minutes, 1 hour, etc.) is one method of traffic counting, whereby the total vehicular traffic is required. If from the past traffic counts it is required that a proportion of heavy vehicles is to be determined as a percentage of the total traffic, then such a percentage is applied to the counted volume to get the effective traffic flow. On this basis, the method of traffic counting should be decided before hand and that traffic counting forms and training should be conducted.

Location of Counting Sites

Counting in the open country and in build-up areas is different in nature and in execution. Traffic counting in an open country (rural environment) has a high potential to yield the much-needed concentration by enumerators, while that in the build-up areas is prone to disturbances. The type of disturbances envisaged include movement by enumerators between the counting sites and the built-up environment, such as shops, thus resulting in high error margins in data so collected. It is, therefore, critical that supervision and close monitoring are undertaken at the respective sites falling within the built-up environment for the duration of the counts.

Where traffic counting is to be conducted for an intersection, the number of enumerators required is mainly a function of the type of intersection, the composition of traffic flow, the number of lanes and the anticipated traffic volume. It is, therefore, essential that a proper and detailed site inspection is conducted prior to start of any traffic survey.

Traffic Flow Level

Traffic flow level influences the capability of enumerators to carry out traffic counts manually on high volume roads. Where the enumerator is expected to count more than one traffic lane on a busy road, observational error is commonly encountered. On the other hand, whereas efficiency and capability of traffic enumeration vary from enumerator to enumerator, for a traffic level of less than 1000 vehicles per hour in one direction manual counting by one enumerator can give satisfactory data within the permissible tolerances. For traffic level in excess of 1000 vehicles per hour in one direction, additional enumerators are required or automatic counters should be used.

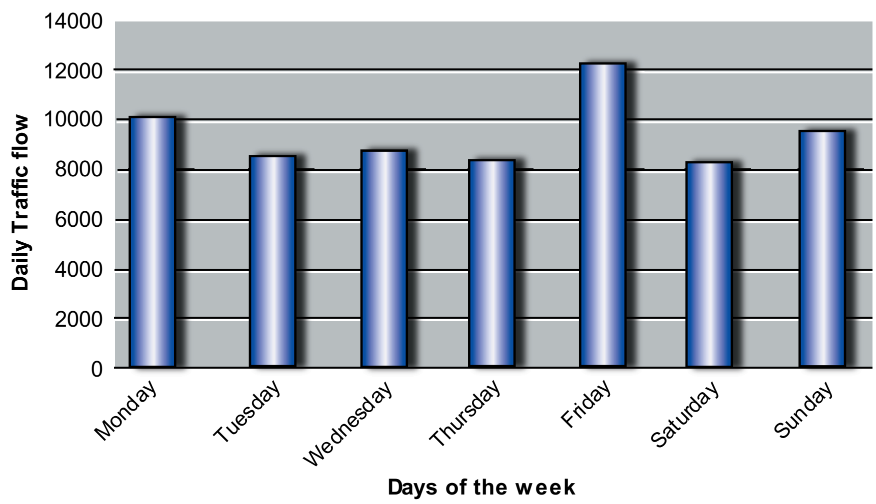


Figure 7.2.1: Different average daily traffic flow levels.

Road Type

The type of road has an effect on traffic counting as it combines both the level of traffic flow and the number of lanes for the specific road. Traffic flow normally follows three different modes and levels, namely:

- Congested or forced low-speed continuous flow;
- Normal continuous flow and;
- Wide spaced high-speed flow.

From the lower level to the upper level of traffic flow there remains an incremental desire for collection of better quality data commensurate with increase in the sample size. This is because with lower volume of traffic the potential for variance in the traffic flow reduces, while with higher traffic volume potential for flow variation over short intervals increases, such as tidal flow or platoon flow.

While taking cognisance of the above traffic flow levels, traffic counting for single carriageways can be handled with manual counting with much reduced risk of error level while dual carriageways would require automatic traffic counters owing to the volume of traffic, the speed and the number of lanes.

Traffic Composition

Traffic composition influences the methodology and approach which should be applied for traffic counting at respective counting sites. This dictates the number of vehicle classes and the quality of data required. It is, therefore, critical that the traffic composition is known prior to the commencement of the survey in order to enforce the measures required.

Widespread or platoon/tidal traffic flow condition.

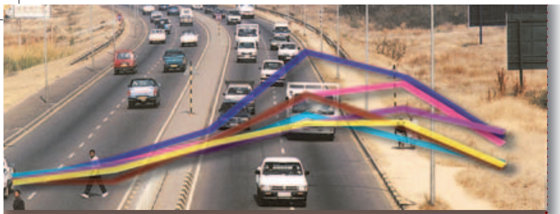
Mixed traffic flow condition.

7.3 Counting Accuracy and Quality Assurance

Quality of sampled data largely depends on, among others, the method followed in the establishment, use and maintenance of the count stations. For automatic counts equipment, close co-operation with the manufacturer is necessary in order to achieve maximum benefits. The operation procedures should be clearly written and detailed for easy understanding by both the client and the supplier.

Common for all methods of traffic counting, classification chart (based on vehicle composition) is required to record the traffic flow by vehicle types. This is because traffic flow is a dynamic process and can fluctuate over time. Accuracy in traffic counting and establishment of these fluctuations in the traffic flow is of critical importance, as this influence derivation of projected traffic. Where there is evidence of increased traffic flow, it is required that the vehicle groups experiencing high growth should be calculated as a percentage of the total traffic counted in the stream. This enables appropriate determination of the impact of the most influential vehicle type(s) on the road being considered and how it influences economic analyses and decision-making.

Where different classes of traffic characteristics shows a differential growth in the stream, average growth rates for each traffic class shall be calculated as the average growth rate for the total traffic counted.



As these calculations can experience errors, it then emphasises the need to undertake proper training before start of traffic counting exercise. In addition, long continuous counts can have cumulated human error due to fatigue and lack of concentration by enumerators, which will then affect the results of the calculations. On the other hand, the short duration counts can result in overestimation of the assessment due to insufficient data. These should be guarded against in order to ensure consistency in data collection and reduced potential for human error.

In this context, the user of the traffic data should know the purpose for which data is being collected and its level of accuracy. Attempts should, therefore, be made in ensuring that there is adequate planning, training of enumerators and a clear understanding of the exercise to be performed.

In order to compensate for possible road dependant factors, calibration facilities are desirable. Some automatic counting equipment have automatic calibration, while others can only adjust the sensitivity or tolerance. Some have the arrangement to adjust the loop length using different vehicles with known lengths. The calibration routines have to be conducted according to the instruction given by the manufacturer of the equipment.

The accuracy of traffic counting depends on its duration and variation in the traffic flow. The following examples of accuracy levels for automatic counting are used in Norway, which can be adopted to Botswana conditions after proper statistical calibration for the 90th and 95th percentile confidence levels.

- 6 weeks counting: 4.9 % and 5.8 %
- 4 weeks counting: 7.4 % and 8.7 %
- 2 weeks counting: 9.7 % and 11.5 %
- 1 week counting: 16.2 % and 19.3 %

As the seasonal variation of the traffic flow is very low in Botswana, the length of the counting periods can be reduced as deemed appropriate depending on the quality and end use of the data.

7.4 Duration of Counting

Duration of traffic counts is dependent on the type and quality of data required. Depending on the end use of traffic data being collected, counts at established permanent stations are ideally conducted over 12, 16 and 24 hours continuously for at least seven consecutive days per station. The selection of counts duration will depend on whether the amount of data collected will produce reliable results. This decision will depend on the characteristics of the traffic flow and the type data required for a particular location or project. Typical duration are given in *Table 2.3.1* as shown earlier in this guideline.

Much consideration needs to be taken into account when planning a traffic survey and the relative importance of these will vary with the purpose of the survey. However, it is fundamental that all surveys address questions of **"where"**, **"when"** and **"for how long,"** as these guides the survey process. Clearly the answer depends to some extent, on what the intended

use of the data would be and what is to be estimated, such as peak traffic, average traffic, or any other value. However, the most important parameters to be considered are the accuracy of data and the cost effectiveness of collecting such data. It is therefore important that surveys should produce information required at the lowest possible cost and to a level of accuracy that inspires confidence in decision making for the intended goal.

7.5 Counting Procedures

7.5.1 Intersection

Traffic counting at intersections is dependent on varying geometric conditions, for example; T-junctions, cross roads, roundabouts and signalised intersections and assumes the following operating conditions:

a) The major road traffic flow may be either in a single or in multiple streams in one direction and may vary from low non-congested flow to high congested flow conditions;

b) The minor road flow is generally in a single stream, with the flow varying from low non-congested flow to high congested flow conditions;

c) The gap acceptance of minor road approaching traffic may be presented with a uniform distribution and close to zero opportunities to join the main traffic stream;

d) The minor road traffic flow rises instantaneously from very low flow to a maximum peak value, which is maintained until the end of the peak period after which it falls instantaneously to very low flow and to zero.

Traffic flow condition influences planning for traffic counts.

7.5.2 Straight Roads

Traffic counting on a straight road is done by traffic enumerators who stand by the roadside, counting and classifying the vehicles as they pass. The enumerator thus record vehicles moving in one particular direction. In this case there is no complexity if the level traffic is less than 1000 vehicles per day.

A typical straight road.

7.5.3 Urban Roads

In the context of this Guideline, an urban road is a road located and/ traversing a developed or built-up environment. This type of road may serve as a main arterial or transit route within the urban area, local connector, tertiary, access or even a local street.

As a result, traffic counting for these types of roads can be complex as the function of the road and/or its level of service in the road hierarchy as measured by the traffic flow level dictate it. Further complexity could be presented by the proximity of the access intersections associated with the built environment. On this basis, both manual and automatic counting systems are suitable for traffic data collection along these roads.

An urban road.

A typical single carriageway rural road.

A gravel rural road.

A dual carriageway road requires more resources for traffic data collection.

7.5.4 Rural Roads

These are roads ranging from inter-urban main trunk roads to local minor access roads within a rural set up. However, the emphasis within the confines of these guidelines are placed on the higher order type of roads, such as inter-urban trunk roads, tertiary, connector and main access roads within a rural built up area or between the rural built environment.

These roads could be counted using both manual and automatic counting systems, depending on the level of traffic flow, capacity of the road and resources required to undertake the counts. If counting of these roads is not intended to include intersection or is not undertaken within a built environment the sites should be planned and sighted in an area free of disturbance.

7.5.5 Dual Carriageways

Dual carriageways are roads consisting of more than one driving lane in each direction irrespective of its location. This is whether the road is within an urban or rural environment and it can range from inter-urban freeways to low volume rural connectors, depending on the level of traffic to be served. Functionally, upgrading of single carriageway roads to dual carriageways is a direct result of increasing traffic demand, and it is therefore provided to cater for capacity expansion and improve level of service.

Being a high traffic volume road, it is not always easy to efficiently conduct manual traffic counts on these roads. For efficient collection of traffic flow data on dual carriageways, automatic counters are the most appropriate. This takes into account the volume of traffic and the speed with which vehicles are passing a counting point. However, enumerators could be assigned for manual counting on dual carriageways by allocating each enumerator a lane per direction of flow or just by the direction of traffic flow. This approach will require more enumerators than it is the case with single carriageway roads.

8 TYPICAL CONVERSION OF TRAFFIC COUNTS

8.1 General

Main input parameters for design of the road are the Annual Average Daily Traffic (AADT) and the cumulative loading over the design life of the road (normally 20 years), that is the number of vehicles passing a point in both directions per day taking into account the variation in the traffic flow throughout the year and the total number of axles for the same traffic volume. Determination of the AADT from 12-hour traffic count is achieved by converting to 16-hour flow (the volume of traffic flow counted in hours) by using applicable conversion factors. Having obtained the 16-hour counts, a further conversion to 24-hour flow may be carried out to obtain an Average Daily Traffic flow, and subsequently to Annual Average Daily Traffic. For illustration, the following conversion factors have been used in the calculations:

Scenarios	Urban	Inter-urban	Recreation
High	1.016	1.115	1.271
Mediun	1.000	1.060	1.141
Low	0.989	1.016	0.962

Table 8.1.1: Typical traffic conversion factors.

8.1.1 Conversion of Average Daily Traffic to Annual Average Daily Traffic

Annual Average Daily Traffic is the average traffic that is expected to use a particular road over a year (365 days). The Average Daily Traffic, conversion to Annual Average Daily Traffic is determined from the following expression:

AADT = T-ADT /365.

Where: AADT = Average Annual Daily Traffic.

T-ADT = Total Average Daily Traffic.

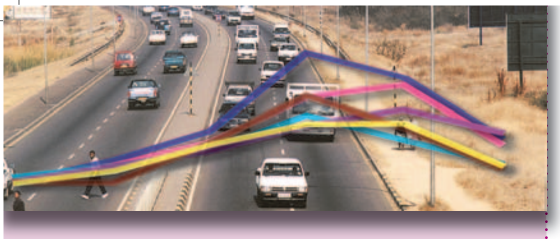
8.1.2 Conversion of Peak Hour Traffic to Average Daily Traffic (ADT)

Peak hour traffic used for design is the traffic, which passes a point during the severest peak hour(s) of the counting period. In order to convert peak hour traffic to Average Daily Traffic (ADT), the peak hour traffic should first be converted to 12 hour or 16-hour traffic flow and then to 24-hour traffic flow. For instance, if peak hour flow is 10% of 16-hour counts, then for any given number of vehicles, ADT is given by the following:

Peak hour flow * Conversion factor = ADT (16-hour)

Then, ADT (16-hour) * Conversion factor = ADT (24-hour)

The conversion factor is the proportion of traffic flow over a given peak time as it relates to that prevailing traffic counted under same traffic conditions and over a specific counting period.



8.1.3 Conversion of Day Time Traffic to Average Daily Traffic

In order to convert Day Time Traffic to Average Daily Traffic and subsequently to Annual Average Daily Traffic, derived factors based on the duration of counts shall be used. For the purpose of illustration the following has been assumed:

Seven (7) day counts is conducted on a busy rural main road.

Constant 16-hour traffic flow counts from Monday to Friday of 10 000 vehicles each has been obtained.

A further 16-hour constant traffic flow for Saturday and Sunday of 8 000 vehicles each was also obtained.

Calculations

7-day 16 hour traffic flow	=	*(5 x 10 000) + (2 x 8 000)*
	=	*66 000 vehicles.*

Using a 95% confidence limit for the 24-hour traffic flow with 5% tolerance.

Then, 16-hour traffic flow is 95% of 24-hour traffic flow, therefore;

7 days 24 hour traffic flow	=	*66 000 / 0.95*	*= 69 474 vehicles*
Average Daily Traffic (ADT)	=	*69 474/7*	*= 9925 vehicles.*

Common traffic conditions in an urbanised area.

As for the Annual Average Daily Traffic (AADT), the derived Day Traffic is converted as follows:

AADT	=	*9925 x conversion factor*
	=	*9925 x 1.141 (considering medium scenario)*
	=	*11 324 vehicles*

8.2 Reference Curves and Short-Term Counts

Reference curves are charts or traffic flow envelopes developed from historical traffic data to reflect average traffic flow levels flow on specific roads or region. It is from these charts that applicable factors are obtained in the calculation and projection of different traffic flow conditions. The curve indicates the traffic flow and how the traffic varies throughout the year.

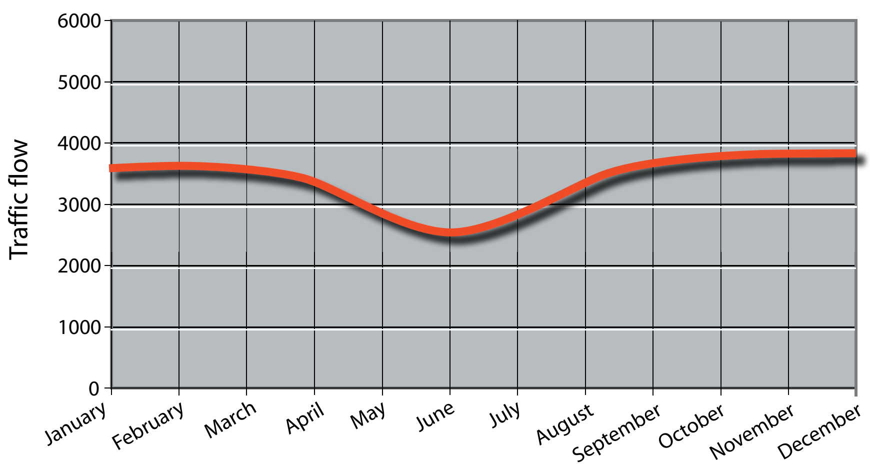


Figure 8.2.1: Reference Curves.

Short-term counts are traffic counts carried out over short durations, typically less than seven (7) days counts. When transforming the short - term count data to Annual Average Daily Traffic (AADT) a reference curve is required for that particular road or the region. The short-term count counts are multiplied by a factor obtained from the reference curve. Different types of roads will have different types of reference curves.

For example, reference curves could be established for, but not limited to the following:

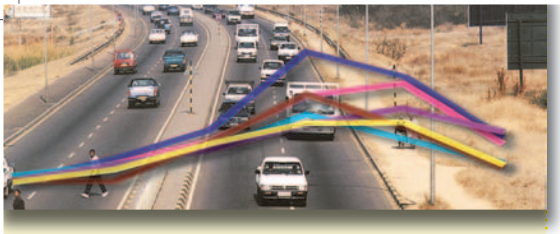
- Collector roads with commuter traffic;
- Roads with commuter and thoroughfare traffic;
- Urban streets;
- Heavily trafficked main roads near a town;
- Normal urban or rural main roads;
- Tourist roads;
- Other roads.

Development of reference curves for the national network is recommended when using a system of both permanent and temporary stations for traffic counting. The reference curves should be adjusted for the representative road network in the country.

The variation of traffic flow over a year may not differ so much from one road type to another, or region to region. As a result many reference curves for different type of roads may therefore be limited or not warranted given the low level of traffic in Botswana.

When carrying out short-term counting the counting period should be free of events or holidays. Day-to-day variations can be minimised by avoiding data collection during weeks containing:

- A Public Holiday;
- Fridays preceding a Public Holiday or Monday after a public holiday;
- Market days within the traffic catchments area or its vicinity;
- Half-day-closing days;
- Days with exceptionally bad weather.



9 ANALYSIS AND PRESENTATION OF TRAFFIC DATA

9.1 General

Analysis of traffic data will vary greatly in complexity depending on the scope and objective of the survey. At the simplest extreme, analysis consists of totalling different categories of vehicles in a volumetric count. At the other extreme, complex surveys may require computer analysis of traffic to journeys, allocation of existing and proposed road network, traffic projections and other related operations/analysis.

9.2 Layout of Analysis

9.2.1 Computer Analysis

For the file system as recommended earlier, almost all PC-programs developed and available for traffic analysis can be used. Most of them will also be in an English version and therefore usable for Botswana conditions.

Traffic data entry for subsequent analysis.

For simulation purposes, an example of the Norwegian computer program Traffic 6 / NorTraf incorporate the following:

- RTDMAN - Program for manual counts.
- CCUENG - Program for control and correction of data.
- AADT2000 - Program for calculation of AADT.
- TRAPRES - Graphic presentation.
- PRIENG - Summaries in a tabular form.

Proper analysis of traffic data is the key to decision making and planning.

A specific system can be developed or purchased depending on the needs of the institution and compatibility with existing systems. Although not exhaustive or prescriptive, the following salient issues should, therefore, be taken into account during the development, improvement or procurement of a traffic data storage and analysis program, particularly for Botswana conditions.

i) Of paramount importance is that, the program should allow the user to enter data manually in pre-set tables, which can be increased or decreased to meet the needs, for any number of vehicle classes. The program should also be able to provide for an interactive or a linked mode system with many other files generated or to be generated during the analysis process;

ii) It should use either a query method or any other format that will be user friendly and appropriate for requesting a specific data or command or action to be taken;

iii) It should include the minimum of the following vehicle classes, which can easily be increased or decreased as required;

a) Passenger Cars
b) Pick-up and Vans
c) Trucks
d) Light Lorries
e) Medium Lorries
f) Heavy Lorries
g) Heavy Buses
h) Mini Buses
j) Agriculture Tractors

iv) For each of the above vehicle classes, there should be provision in the program to enable the user to retrieve or display all vehicles falling within a specific range, by weight, length, axle spacing or distance, etc.

Example:

Car:	Weight Range:		Tons to		Tons
	Length Range:		M to		M
	Axle Spacing:		M to		M

v) The program should not be limited to the above ranges only, and it should allow the user to add on as many parameters or ranges as may be required, in order to conduct a proper analysis;

vi) The program should have an interactive process whereby the user can easily manipulate different files simultaneously to obtain a specific analysed data by either using the above suggested ranges, limits or parameters;

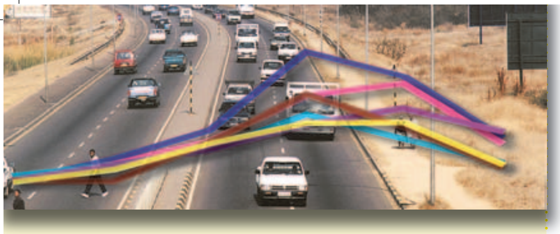
vii) Subsequent to vi) above, the program should allow the user to im mediately create or produce graphic files of any kind desired by the user which should be plotted individually or as a combination, such as linear graphs, pie charts, bar charts, etc. as may be required;

viii) Where automatic counting systems are used, the program should allow the user to make the necessary adjustments to accommodate the requirements of the system in use and ensure compatibility, so that the resulting output can be shown (as part of the statistical traffic flow data) in the form of weight per axle i tonnes, speed in km/h of each vehicle, gross weight of each vehicle and any proportion of overload in tonnage and percentages.

9.2.2 Manual Analysis

The essential part of any data collection process is to be analysed and presented in a format that is easily understandable. Below is an illustration of a simplified manual counts data analysis, as transformed from field data collection form shown in ***Appendix B.***

Manually collected raw field data is immediately analysed upon receipt from outstations.



Station	Place	Section of the road or Direction	Cars	Vans	Trucks	Light Lorries	Medium Lorries	Heavy Lorries	Heavy Buses	Mini Buses	Total
		Jwaneng	11	61	54	17	4	8	3	2	**160**
S22	Kang Fork	Morwamosu	2	9	31	7	3	5	1	0	**58**
		Gantsi	2	11	32	7	3	6	1	0	**62**
S24	Morwamosu	Sekoma	8	24	60	15	4	10	3	1	**125**
W5	Gantsi West	Kalkfontein	0	6	33	5	2	2	0	0	**48**
		Gantsi	0	6	36	4	2	3	0	0	**51**
W6	Charleshill	Mamuno	1	7	26	3	1	4	1	1	**44**
		Kalfontein	1	8	35	7	2	3	1	1	**58**
W7	Kalkfontein	Charleshill	0	6	26	3	1	2	1	0	**39**
		Gantsi	0	6	30	4	1	2	1	0	**44**
S1	Kanye South	Kanye	88	205	93	39	6	10	31	7	**479**
		Lobatse	80	187	79	32	6	11	26	5	**426**
S2	Lobatse South	Lobatse	468	816	332	65	18	49	56	87	**1891**
		Kanye	277	488	190	44	11	21	51	22	**1104**
S4	Moshaneng	Kanye	152	318	180	66	14	38	10	38	**816**
		Jwaneng	147	314	174	62	12	29	11	38	**787**
S10	Lobatse T.T.C	Lobatse	101	105	42	9	4	28	0	7	**296**
		Pioneer B/Post	99	93	41	9	3	26	0	7	**278**
S12	Jwaneng	Jwaneng	74	153	80	27	6	14	6	21	**381**
		Kanye	72	156	77	25	6	16	6	21	**379**
S21	Jwaneng	Jwaneng	11	61	54	17	4	8	3	2	**160**
		Sekoma	12	63	52	16	4	8	3	2	**160**

Table 9.2.1: Typically analysed manual traffic count data.

9.3 Data Entry and Analysis

9.3.1 General

Data entry and analysis is undertaken in two distinct forms, namely; manual and computersied. Where computerised system is not in use manual entry in summary forms are used, which is then transferred to analyses forms. Where computerised system is in place, data entry and analysis should allow for direct manual entry of data in the system. However, changes to data entered and formatting of forms should be coded to prevent it from any undue changes.

9.3.2 Data Entry

Data entry menu provides a means of entering collected traffic data from the collection forms received from the counting sites into a computerised system. The data entered in the system should be cleaned of errors before it is summarised and analysed. The summary program processes each link in the network accumulating detailed data for each representative section and produce summary records for each of the road section. Once the data has been summarised for each station, on regional or national basis, the system should not allow for the same data to be summarised again unless the condition or inventory of data entered has changed.

9.3.3 Data Analysis

The analysis process should permit the user to obtain, among others, the following reports:

- Defined vehicle types and counting stations;
- Conversion of data in different formats into a common data format;
- Calculation of Traffic Growth Rates of traffic volumes;
- Production of forecasts based on historical data and growth rates.

The analysis of the summarised data uses conversion parameters set up by the user or administrator, and where parameters are not defined default system parameters could be used.

In the calculation of traffic growth rates where data is available, the system should generate growth rates and updates the user growth rates unless the user has already defined a growth rate. In this case, the system calculates the growth rate as a percentage change in traffic volume per year per vehicle category. Where historical data is not available, extrapolated growth rates are determined, whereby the system takes all available traffic and produces an estimated growth rate.

9.4 Reporting

Whatever program is used to analyse traffic data collected, it should satisfy the specific needs of the user, and allow the user to search vehicles of similar characteristics and be able to send such information in graphic forms as may be required to meet the intended reporting format. This query computation should either be done for a particular parameter, range or limit on stages (in series) or to be carried out at the same time (in parallel) by selecting a group of parameters.

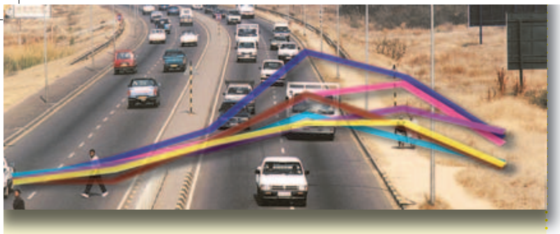
In processing the reporting modules, the user should be able to produce summary tables of different characteristics of vehicles from the general tables into which raw data was entered or from analysed data as required by the user.

The program used should be able to produce reports of Average Daily Traffic (ADT) for any period of the year, as well as Annual Average Daily Traffic (AADT), traffic growth factors, etc.

As determination of the correct traffic growth factors are very important for projection of traffic flow, the program should enable the user to request for growth factors and percentages over a specific period in time (weeks, months, years), or as required for each road, group of roads and for the country. These growth factors should be easily turned into traffic growth envelopes or standard curves to be used in checking data quality and projection for planning purposes. Further, the program should be able to generate growth factors for each counting station in weeks, months, years, as required. Sufficient projections based on historical traffic trend, potential economic development indicators or GDP growth, etc over a period should be easily undertaken by the selected program.

9.5 Presentation

Information on raffic data is not always easily accessible. It is recommended that simple maps or graphs should be produced for presentation



of summary information. This presentation will assist where staff not familiar with such traffic census figures as presented only in a table does not easily read out AADT for the various roads.

These maps may be supported by graphs and tables, showing the typical hourly, daily and yearly traffic flow pattern. This will give useful and comprehensive information of the traffic volume data on the road network.

Year	Cars	Vans	Trucks	Light Lorries	Medium Lorries	Heavy lorries	Heavy Buses	Mini Buses	Total
1990	308	498	294	104	21	84	22	35	**1366**
1991	285	572	254	110	22	98	20	37	**1398**
1992	326	668	188	119	27	112	21	44	**1505**
1993	297	723	318	104	23	91	34	37	**1627**
1994	284	739	335	110	16	57	46	30	**1617**
1995	392	945	366	123	22	75	57	30	**2010**
1996	377	885	324	115	22	73	45	30	**1871**
1997	406	789	399	132	22	106	63	31	**1948**

Table 9.5.1: Summary AADT for different vehicle groups.

Year	Palapye Direction	Mahalapye Direction	M/Drift Direction
1990	1366	1141	250
1991	1398	1207	239
1992	1505	1418	296
1993	1627	1121	338
1994	1617	1399	326
1995	2010	1703	358
1996	1871	1532	348
1997	1948	1596	388

Table 9.5.2: AADT by direction of flow.

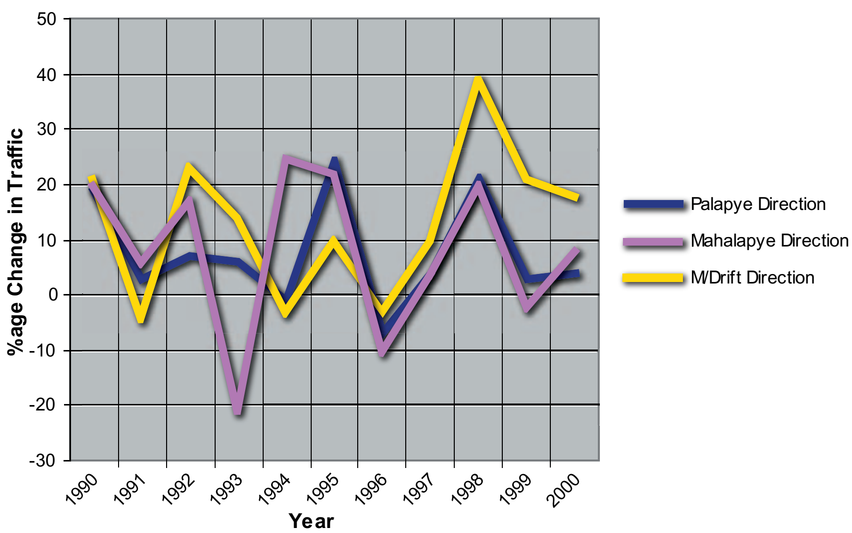


Figure 9.5.1: Typical traffic flow variations.

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APPENDICES

APPENDIX A 1: Monthly Traffic Census Count Survey Form

ROADS DEPARTMENT, BOTSWANA

MONTHLY TRAFFIC CENSUS COUNT SURVEY FORM

PLACE.. CENSUS POINT No..................................DIRECTION COUNTED...

MONTH AND YEAR.. No. OF DAYS...

Day	Cars		Pick Ups or Vans		Trucks		Light Lorries		Medium Lorries		Heavy Lorries		Heavy Buses		Mini Buses		Agric Tractors		Total No. of Vehicles	Total No. of Axles
	No.	Axles	No.	Axles	No.	Axles	No.	Axles	No.	Axles	No.	Axles	No.	Axles	No.	Axles	No.	Axles		
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28																				
29																				
30																				
31																				
Total																				
Average																				

APPENDIX A 2: Road Traffic Census Count Survey Form

ROADS DEPARTMENT, BOTSWANA

ROAD TRAFFIC CENSUS COUNT SURVEY FORM

Year…………………..

Representative of………………………….. Section

Place………………………… Station……………….

Average Per Day

Type of Vehicle Month	Cars	Pick ups or Vans 1,5 TonS	Trucks 1,5 -4,99 Tons	Light-Lorries 5-9,99 Tons	Medium Lorries 10-19,99 Tons	Heavy Lorries 20 Tons and over	Heavy Buses	Mini Buses	Agric Tractors	TOTAL
January										
February										
March										
April										
May										
June										
July										
August										
September										
October										
November										
December										
TOTAL										
MEAN										

APPENDIX A 3: Traffic Census Survey Form

Date:... To.................................
Time from:...
Direction Counted:...
Enumerater:...
Counted Heading: Beginning of day:...

Place:..
Census Point No.:.....................................
Weather:...
Sheet No.:...
End of Day:..

Put an oblique stroke(/) for each vehicle in consecutive squares. When the squares for any period full additional vehicle noted by crossing oblique stroke

	No. of Vehicles	TOTAL	No. of Axles	TOTAL	Load Axles
Cars					
Pick up or Van Less than 1,5 Tons					
Trucks 1,5 - Less than 5 Tons					
Light Lorries 5 - Less than 10 Tons					
Medium Lorries 10-20 Tons					
Heavy Lorries over 20 Tons					
Heavy Buses					
Mini Buses					
Agric Tractors					

APPENDIX B 1: Summary Traffic Data for Trans Kgalagadi Highway - 1990

Trans - Kgalagadi Highway Traffic Data (Jwaneng and Kang Road - 1990)

Station	Place	Section of the Road or Direction	Cars	Vans	Trucks	Light Lorries	Medium Lorries	Heavy Lorries	Heavy Buses	Mini Buses	Total
S22	Kang Fork	Morwamosu	0	0	9	7	2	3	0	0	21
		Gantsi	0	0	8	6	2	3	0	0	19
S24	Morwamosu	Sekoma	0	0	63	25	8	6	1	0	104
		Kang	0	0	29	12	3	2	0	0	47
W6	Charleshill	Mamuno	0	1	9	2	1	3	0	0	16
		Kalkfontein	0	1	11	3	1	1	0	0	17
W7	Kalkfontein	Charleshill/Gantsi	0	1	27	5	1	1	0	0	35
S20	Kang Fork	Kang/ Morwamosu	0	1	31	12	3	4	0	0	51
S25	Sekoma	Marwamosu	0	2	33	17	3	4	0	0	59
		Jwaneng	0	5	53	24	4	4	0	0	90
S1	Kanye South	Kanye	219	440	251	111	12	27	39	15	1114
		Lobatse	214	382	214	95	11	16	21	13	966
S2	Lobatse South	Lobatse	487	764	311	57	20	68	51	34	1792
		Kanye	308	490	192	54	11	19	6	25	534
S4	Moshaneng	Kanye	83	196	143	51	11	19	6	25	534
		Jwaneng	98	173	128	50	8	18	7	24	506
S	Jwaneng	Jwaneng/Kanye	91	166	124	53	7	16	8	28	493

APPENDIX B 2: Summary Traffic Data for Trans Kgalagadi Highway - 2000

Summary of Traffic Data for Trans - Kgalagadi Highway 2000

Station	Place	Section of the Road or Direction	Cars	Vans	Trucks	Light Lorries	Medium Lorries	Heavy Lorries	Heavy Buses	Mini Buses	Total
S22	Kang Fork	Morwamosu	32	18	41	14	3	23	0	4	135
		Gantsi	36	24	59	13	4	23	5	5	169
S24	Morwamosu	Sekoma	50	53	98	23	6	27	8	7	272
		Kang	52	53	99	25	8	27	9	8	281
W6	Charleshill	Mamuno	36	29	66	7	4	25	2	6	175
		Kalkfontein	33	30	91	13	4	26	4	8	209
W7	Kalkfontein	Charleshill	17	17	55	8	2	14	1	5	119
		Gantsi	18	16	54	8	3	14	2	5	120
S1	Kanye South	Kanye	182	288	109	49	8	16	33	11	696
		Lobatse	188	282	108	43	7	14	30	12	684
S2	Lobatse South	Lobatse	851	954	448	83	18	77	73	199	2703
		Kanye	624	656	295	56	12	32	64	77	1816
S4	Moshaneng	Kanye	247	459	241	83	16	82	28	31	1187
		Jwaneng	225	415	223	75	16	135	27	29	1145
S10	Lobatse T.T.C.	Lobatse	132	130	59	11	7	42	0	7	388
		Pioneer B/Post	118	121	51	12	4	43	2	6	357
S12	Jwaneng	Kanye	128	223	111	35	6	34	19	17	573
		Jwaneng	146	244	122	38	8	30	20	17	625
S21	Jwaneng	Jwaneng	39	91	83	21	5	17	9	5	270

APPENDIX C: Abbreviations

AADT	Annual Average Daily Traffic
ADT	Average Daily Traffic
DFID	Department for International Development, UK
GCSE	General Certificate of Secondary Education
NORAD	Norwegian Agency for Development Cooperation
NPRA	Norwegian Public Roads Administration
O-D	Origin – Destination Surveys
PHN	Public Highway Network
UHF	Ultra - Highfrequencies
WIM	Weigh – in - Motion