IMPROVING PUBLIC PASSENGER TRANSPORT IN KUMASI BY USE OF HIGH OCCUPANCY VEHICLES (HOVs) – CASE STUDY OF METRO MASS TRANSIT (MMT) BUS OPERATIONS ON THREE ROUTES

By

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DECLARATION

I hereby declare that this submission is my own work towards the MSc. and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

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DEDICATION

This work is dedicated to my sweet sons

Kevin Sedem Gbeckor - Kove

and

Darrell Seyram Gbeckor – Kove

I love you so much.

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I am most grateful to the Lord God Almighty for seeing me through my studies. The climax of it all was just by his grace and for this I am very thankful.

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ABSTRACT

In Ghana, the "trotro" is the main public transport mode in cities. The privately owned public transport operators include the Ghana Private Road Transport Union (GPRTU), Progressive Transport Owners Association (PROTOA), Co-operatives and several others. The public transport services are characterized by low journey speeds, long travel times, long turn around times, etc. in the urban areas which results in the loss of productive man hours.

The Metro Mass Transit Bus Service (MMT) was introduced as a parastatal bus service following government's policy to reintroduce mass public transportation bus services. They operate inter-regional, inter-city and intra-city services.

This study sought to identify how public passenger transport can be improved by use of High Occupancy Vehicles (HOVs). The MMT bus service which uses HOVs was used as a case study. The overall aim is to make their services attractive, increase patronage and increase their numbers on the roads. This can facilitate reduction in congestion and improve journey times and speeds.

In this study, three (3) out of the eight operational routes of the intra city services were selected. Data on the composition of traffic, travel time, delay and journey times were collected. Observations were made to identify location of bottlenecks and their contributory factors. In-vehicle studies to observe loading and offloading patterns, bus journey times and speeds were also collected.

The factors contributing to congestion were identified as high composition of low occupancy vehicles especially cars, taxis and "trotros", indiscipline driver and pedestrian behavior, type of Intersection Control Device, poor road condition and unregulated road side parking and activities.

The results indicate that Taxis which constitute 33% of the stream carry only 17% of passengers per hour, "Trotros" which constitute 27% of vehicles carry 50% of passengers per hour, Private vehicles, mainly cars form about 25% and carry 7% of passengers per hour, Buses, that is

vehicles carrying more than 23 passengers including MMT vehicles constitute about 9% of the vehicle fleet but carry 21% of passengers per hour.

Most passengers are however carried during the morning and evening peak periods.

Average journey speeds recorded are between 9km/hr - 14km/hr, 8km/hr less than previously reported indicating worsening congestion situations. Lowest speeds recorded within dense areas are between 4.5km/hr – 9km/hr. A round trip journey time along the routes was between 1.5-3 hours. The parameters indicate worsening congestion situations along the routes, this making it even more difficult for the MMT to carry more passengers per day.

Recommendations made include the use of HOV's for public transport and for high patronage, the MMT buses should operate during the morning and evening peak periods. Drivers should be educated on the use of laybyes, shoulders and the roadway in general. The Tafo and Atonsu lorry stations should be relocated. It is also recommended that the major intersections along the routes that are priority controlled should be signalized and buses be given queue jumps at signalized intersections. Other measures include the development of terminals for the MMT buses and for the KNUST Community.

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LIST OF ABREVIATIONS

ACON	– Associated Consultants
ADB	– Agricultural Development Bank
BRT	– Bus Rapid Transit
CBD	– Central Business District
CES	– City Express Services
DUR	– Department of Urban Roads
GHA	– Ghana Highway Authority
GOIL	– Ghana Oil Company Limited
GPRTU	– Ghana Private Road Transport Union
HOV	– High Occupancy Vehicle
ICD	– Intersection Control Device
KNUST	– Kwame Nkrumah University of Science and Technology
LOS	– Level of Service
LOV	– Low Occupancy Vehicle
MMT	– Metro Mass Transit
MTTU	– Motor Traffic and Transport Unit
NIB	– National Investment Bank
OSA	– Omnibus Services Authority
ROW	– Right of Way
SIC	– State Insurance Company
SSNIT	– Social Security and National Insurance Trust
STC	– State Transport Corporation
UTP	– Urban Transport Project
PROTOA	– Progressive Transport Owners Association

CHAPTER ONE

1.0 INTRODUCTION

1.1 Introduction to Public Transport

Transportation is the movement of goods and people from one location (origin) to the other (destination). Transportation needs have increased over the years due to increase in population, increase in economic prosperity and urbanization. This thus poses a great challenge to transportation professionals of the need to develop efficient and effective transportation systems to deal with the issues such as urban mobility and accessibility.

The desire of people to move and the need for goods to be transported creates the demand for transportation. The mode of transportation used (air, road or water) is influenced by time, money, comfort and convenience.

Public transportation involves all transportation systems in which passengers do not travel in their own vehicles (even if they own one). Public transportation is aimed principally at providing transportation to the transportation disadvantaged groups in society. These are people who do not have any means of transport other than a public transport known as captive riders and people who have private cars but decide to use public transport because they may be cheaper and more convenient as compared to their personal cars. These people are known as choice riders. Public transport is therefore service available for use by the general public.

Public transportation plays a very vital role in the productivity of cities and large towns by aiding in the transfer of passengers, goods and services which in turn has direct bearing on the national economy.

Road based public transportation has risks of being considerably slower than private vehicles if it gets held up in general traffic congestion. In addition, the scheduled vehicles have to make frequent stops to board additional passengers.

In Ghana, a developing country, the argument for the provision of public transportation include, the rapid increase in population and urbanisation, lateral growth in land use, low car ownership, high vehicle operation cost and access for those who can not and/or do not choose to drive. There is therefore the need to move people and goods from one location to the other.

Over the years, the municipalities in various regions of Ghana provided public transportation services. Later, the Government, made several attempts to provide public transportation for the people. Efforts at providing bus based urban public transportation in cities in Ghana include the "TATA" buses and the "Omni Bus" Services Authority popularly known as OSA, more than two decades ago. Both initiatives collapsed after a few years of operation.

In cities such as Accra, Kumasi, Tema and Takoradi, the urban public transportation system is dominated by the private sector and decisions affecting services, scheduling and fares are purely in the purview of the providers. The dominant service provider is Ghana Private Road Transport Union (GPRTU) followed by Progressive Transport Owners Association (PROTOA) and several others.

Following an election promise in 2000, the government in 2003, introduced the Metro Mass Transit (MMT) bus services in some cities which was later expanded to all metropolitan and municipal areas in the country. This has been in operation till date operating inter-city, intra – city and inter regional services.

1.2 Problem Statement

Public transport in Kumasi is dominated by the use of "trotros" and taxis. These have contributed to the high levels of congestion experienced on the arterial roads.

In Ghana, several attempts have been made in the last two decades to establish a public transportation system by use of HOVs to enable people and goods to move from one location to the other. However, these have been unsuccessful.

The recent is the Metro Mass Transit Services Limited, which provides intra-city and intercity services. The intra-city service which is the focus of this study is faced with numerous challenges.

The bus services are faced with long travel times. This is attributed to the high level of congestion on the road. Some delays are also experienced at the intersections since the buses queue with all other modes and have to wait till they get a green to move. There is also heavy pedestrian activities along the road which causes vehicles to slow down. There are no adequate demarcated bus stops and so some stops are influenced by passengers who alight and board the bus and this also adds up to the long travel times. The bus services are also infrequent and unreliable. There are no fixed schedules and passengers are not sure when a bus may arrive at a bus stop for them to board. Passengers spend long waiting times for the bus since the services are irregular and infrequent.

The MMT buses share the same road space with all other vehicles on the routes on which they operate. They do not have any priority over other vehicles along the route and this also adds up to the delays and the long travel times.

The service is thus not attractive to most people except for transit captives who have no other choice. So the question remains as to how to improve these services so that most people would be attracted to it to increase their numbers on the routes. It is in this vein that the following objectives were set for the study.

1.3 Objectives

The objectives for the study are:

1. To determine the passenger trips for the various modes of travel on the selected routes
2. To determine the operational parameters of the Metro Mass Transit bus services namely the load factor, cycle time, journey speed, distance between stops and ridership on selected routes.

3. To investigate how increase in HOVs can be used to reduce congestion and increase passenger travel.

1.4 Scope

The road network for Kumasi consists of radial and grid-like routes. All the major arterials are radial beginning from the city center outwards. The MMT services operate on these major arterials which are nine in all.

The study was done on three strategically selected routes namely the 24th February road, the Mampong road and the Lake road. A study by BCEOM/ACON, 2004, indicates that these routes are highly congested and fall within the first five congested routes in Kumasi.

1.5 Justification

The Government of Ghana through the Ministry of Roads and Highways has a strategy to reduce congestion on all the arterials in the country. One way of doing this is to encourage the use of high occupancy vehicles (HOVs) for public transport. For this to be successful, the services of MMT which uses HOVs have to be attractive in order to encourage people to use the service and remain in operation.

It is expected that when measures are put in place to improve the services, more people would be attracted to it thus reducing the numerous use of low occupancy vehicles and subsequently reducing congestion on our routes.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Public Transportation in Developing countries

Public transportation provides mobility for people and goods within urban areas, between urban areas, urban and rural areas and within rural areas. Most trips in developing countries are made by public transport or on foot. The use of private cars is generally low though growing steadily. Increases in urban populations have in turn resulted in massive increases in demand for transport. Other factors adding significantly to the level of demand are the spread of urban areas leading to longer and more motorized trips, increase in commercial and industrial activities and a greater propensity to travel where incomes have risen. In most cities, because of these factors demand for public transport in particular, has grown even faster than the population (Armstrong - White, 1993).

The public transportation modes are rail or bus but the most dominant in developing countries is bus transportation. This is because, it is the mode that majority of inhabitants can afford since they are low income earners. Buses and minibuses dominate also because they are generally at a level of technology compatible with local expertise and facilities (Armstrong - White, 1993).

Public transportation services in many developing countries do not meet the basic quality of service requirements (see table 1) due to traffic congestion, frequent vehicle breakdowns as a result of poor maintenance standards, lack of investment in vehicles and spares, restricted access to funds and inappropriate Government regulation and control of routes and choice of vehicles (Armstrong - White, 1993).

The excessive traffic congestion has contributed to long travel times and low journey speeds thus making the service unattractive.

While traffic volumes are usually below the theoretical capacity of the roadways, congestion is often extensive due to poor intersection layouts and a lack of traffic control coupled with indiscriminate parking and street trading (Armstrong - White, 1993).

Table 1: Quality of service indicators for bus operations

1	**Waiting time**	
	Passenger waiting time at bus stops	
	Average	5-10 minutes
	Maximum	10-20minutes
2	**Walking distance to bus stops**	
	Dense urban areas	300-500m
	Low-density urban areas	500-1000m
3	**Interchanges between routes and services**	
	The number of times a passenger has to change buses or other modes on a journey to or from work:	
	Average	0-1
	Maximum (less than 10% of commuters)	2
4	**Journey times**	
	Hours travelling each day to and from work:	
	Average	1.0-1.5
	Maximum	2-3
5	**Journey speeds of buses**	
	Dense areas in mixed traffic	10-12kmph
	Bus only lanes	15-18kmph
	Low density areas	25kmph
6	**Travel expenditure**	
	Household expenditure on travel as a percentage of house hold income	10

Source: public transport in third word cities by Alan Armstrong-White, 1993.

2.2 Transit Mode Classification

According to Khisty and Kent Lall, 2006, the classification of modes can be done for transit based on three characteristics namely right of way (ROW), technology and type of service.

The ROW is the strip of land on which the transit vehicle operates. There are three basic ROW categories distinguished by the degree of separation from other traffic. Category A is the grade separated or exclusive ROW which if fully controlled without any crossings or any legal access by other vehicles resembling a freeway system. Category B includes ROW types that are longitudinally physically separated from other traffic but with grade crossings and intersections. Category C consists of surface streets with mixed traffic. Most bus systems and streetcar systems fall into this category.

Classification by technology is concerned with the mechanical features of the vehicles and the riding surface. This involves the support between the vehicles and the riding surface, the steering or guidance of vehicles, the method of propulsion and the means of regulating or controlling the vehicles longitudinally.

Transit services are classified into three groups by the types of routes and trips served. The short haul is a low speed service within small areas with high travel density such as the CBD. The city transit serves people needing transport in the city and it's the most common type of service. The third group which is the Regional transit serves long trips with few stops and generally has high speeds.

2.3 Characteristics of Transit Operations

Khisty and Kent Lall, 2006, have classified transit operations into four categories namely; System performance which refers to the performance elements of the entire system which include Service frequency, Operating speed, Reliability and Safety.

The level of service (LOS) relates to the overall measure of all service characteristics affecting users. These are performance elements such as operating speed, Reliability and Safety and service quality which consists of the qualitative elements of service such as convenience and simplicity of using the system, riding comfort, waiting time, cleanliness and aesthetics and behavior of passengers.

The third category is the Impact on surroundings which could be positive or negative. Short-run impacts include reduced street congestion, changes in air pollution, noise and aesthetics along a new line. Long-run impacts consist of changes in land values, economic activities, physical form and social environment of the city.

The fourth category is Costs and consists of Capital cost for the infrastructure and transit units and the Operating costs which are the regular costs incurred during the operation of the system.

2.4 Level of Service (LOS)

The LOS describes in a qualitative way the operational conditions for traffic from the viewpoint of the road user. It gauges the level of congestion on a highway in terms of variables such as travel time and traffic speed. Six levels of service are described ranging from A (best) to F (worst) (Rogers, 2003).

LOS A represents free flow conditions where traffic flow restraints are virtually zero. Only the geometric features of the highway limit the speed of the car. Comfort and convenience levels for road users are very high as vehicles have almost complete freedom to manouvre.

LOS B represents reasonable free flow conditions. Comfort and convenience levels for road users are still relatively high as vehicles have only slightly reduced freedom to manouvre. Minor accidents are accommodated with ease although local deterioration in traffic flow conditions would be more discernable than in service A.

LOS C delivers stable flow conditions. Flows are at a level where small increases will cause a considerable reduction in the performance of the highway. There are marked restrictions in the ability to manoeuvre and care is required when changing lanes. While minor incidents can still be absorbed, major incidents will result in the formation of queues. The speed chosen by the driver is substantially affected by that of the other vehicles. Driver comfort and convenience have decreased perceptively at this level.

LOS D The highway is operating at high-density levels but stable flow still prevails. Small increases in flow levels will result in significant operational difficulties on the highway. There are severe restrictions on the driver's ability to manoeuvre, with poor levels of comfort and convenience.

LOS E Represents the level at which the capacity of the highway has been reached. Traffic flow conditions are best described as unstable with any traffic incident causing extensive queuing and even breakdown. Levels of comfort and convenience are very poor and all speeds are low if relatively uniform.

LOS F describes a state of break down or forced flow exceeding capacity. The operating conditions are highly unstable with constant queuing and traffic moving on a 'stop-go' basis.

2.5 Types of Transit Systems

There are various types of transit systems. These are

- Rapid rail transit – this is also known as metro, underground or subway and operates on exclusive right of way at relatively high speed with off vehicle fare payment.
- Light rail transit – these are trains operating individually or in short trains with electric motor. It shares the same ROW with other vehicles with rails flushing with the street.

- Bus transit – these are buses on fixed routes with fixed schedules operating individually or articulated with rubber tyres. Their services could be express or regular.

- Taxis – these are automobiles operated by a driver and hired by users for individual trips, tailored entirely to the user's desire (Khisty and Kent Lall, 2006). In developing countries however, the most common are shared taxis in which several passengers, not in the same party are carried together and pay separate fares. (Armstrong, 1993).

- Carpools – these are prearranged ride-sharing services where parties of two or more people travel together in a car on a regular basis. It is a private transport and therefore cannot be organized, scheduled or regulated by an agency but can be encouraged by employers.

- Van pools – these are privately or publicly provided vans (7-15 seaters) transporting groups of persons to and from work on a daily basis (Khisty and Kent Lall, 2006).

2.6 Public Transportation in Ghana

Road transport is the principal mode of transport for both freight and passenger in Ghana. It is estimated that only 15% of road users use private car and the other 85% travel by foot or make use of public transport (www.metromass.com).

Factors that have contributed to the argument for the provision of public transport services in Ghana are rapid increase in population, urbanization and the rapid growth along urban peripheries, low car ownership and congestion among others.

The urban growth which takes place in mostly low-income suburbs of urban centres has resulted in massive increases in demand for travel. These people need to be moved to the attractors most often located in the central business district (CBD) and back to their respective origins at the end of the day.

Public transportation dates as far back as 1898 when the first rail line was constructed from Takoradi to Tarkwa for the commercial exploitation of gold and the first road created between Accra Harbour (now Jamestown) and Dodowa to Larteh in 1905 for the export of palm fruits (Wilson, 2006)

In 1927, the Accra town council operated bus services in Accra, Kumasi, Sekondi-Takoradi and Obuasi. Governments over the years have established bus service companies such as the Omnibus Services Authority (OSA), State Transport Company (STC) and City Express Services (CES). These have however not been successful in their operations and this caused the Government to divest STC and CES and liquidate OSA in the 1990s (Wilson, 2006).

Today, the private sector has dominated in the provision of urban transportation services in the country. Studies by the World Bank indicates that the private sector accounts for more than 75% of all bus trips in the third world (Armstrong - White, 1993).

The "trotro" is the most common means of intra-city public transportation all across the country. It has a full occupancy of 9-12 passengers. "Trotro" refers to the little amount that should be paid from one location to the other. Shared taxis also constitute a great deal of intra-city public transportation in the cities. It is said that Ghana is the country with most taxis in the world (www. metromass.com). It has a full occupancy of 4 passengers. Passengers on same route share same taxi but may pay different fares depending on their final destination.

In Ghana, the private sector provides 95% of transport services with their services being unreliable, uncomfortable and unsafe (Wilson, 2006). The public transport services are unscheduled and operate on the "fill and move" principle from their loading points. Most of these "trotros" and taxis are old, have rusty bodies and dilapidated seats. Passengers are thus exposed to a lot of unsafe conditions when they board these vehicles.

These private operators have formed themselves into unions and take decisions on which routes to ply, however fares to be collected are fixed by the Government. The Ghana Private Road Transport Union (GPRTU) is the main body of the private transport operators.

Nevertheless the private sector has also had its fair share of the challenges that confront their operations.

There has been no clear comprehensive policy on public transport. Operators are subjected to minimal regulation in terms of the authority to operate as commercial vehicles, area of coverage, standards of operation, maintenance of vehicles and related emissions. This has led to the freedom to enter the sector and leave at will. These operators do not receive any financial assistance from the Government in the procurement of new vehicles, vehicle spare parts, maintenance equipment and tyres as all these are foreign exchange intensive. Reactive repair maintenance is often preferred to preventive maintenance, as such, vehicles experience frequent breakdowns and ultimately fail to live up to the recommended technical lifespan. The vehicles are not replaced and as they get older, cost of operations and maintenance soar up and eventually operations are brought to a halt (Wilson, 2006).

The urban transport system in Ghana is characterized by congested central areas of the cities, poor quality of service from public operators, high exposure to road accidents and poor environmental standards. This is seen in the long commuting times and journey delays, lengthy waiting times for public transport both at and between terminals, high accident rates and localized poor air quality. These have resulted from factors such as poor terminal organization and management, use of small vehicles for public transport which contributes significantly to congestion on the roads, poor planning and control procedures for land use development resulting in additional traffic congestion and lack of funding (local and foreign) available to operators who are thus unable to replace their existing vehicle stock with more modern, efficient and comfortable buses. (Kwakye and Fouracre, 1998).

The congestion experienced on the roads in the major cities (especially Accra and Kumasi) in Ghana is also attributed to the inefficient use of the road space available and the controls at the intersections. Walkways have been taken up by traders, vehicles are parked anyhow by the road side and heavy presence of road side activities in the urban areas have all contributed to the congestion experienced on the roads.
A travel time and delay studies on selected arterial routes in Kumasi indicated that as much as 73% of delays on the routes is due to congestion (Jack, 2008)

Since road transport is the main means of transporting goods in Ghana the roadway is shared by heavy goods vehicles as well and this has contributed to the rapid deterioration of the existing roads. In addition the neighboring countries also use these same roads for freight transport and the damage caused can not be overemphasized.

Other important factors which contribute to the success of public transport are fuel and fares which the private operators have no control over. Fares are fixed by the Government and fuel prices are determined by the price of crude oil in the international market (Wilson, 2006).

In line with the objectives of Ghana's vision 2020, the key policy objective for the transport sector is to establish an efficient and modally complementary and integrated transport network for the movement of people and goods at least cost throughout the country. In the urban context, the objectives include improving accessibility, enhancing quality urban travel, minimizing cost of service provision and minimizing environmental impact. The action program for implementing the policy is the Urban Transport Project (UTP) (Kwakye and Fouracre, 1998).

The Ghana National Transport Policy, stated to prioritize mass transportation in urban areas with the aim of moving at least 80% of passengers. The strategy to achieve this is to implement the Ghana Urban Transport Project (GUTP) including the Bus Rapid Transit (BRT) and school busing scheme (Ghana National Transport Policy, 2008).

The UTP in its feasibility study identified that about 70% of people use public transport which utilizes just a third (1/3) of the road space. It also noted the long walking, waiting and travel times. Mini buses ("trotros") which were in dominant use were observed to be old and badly maintained coupled with poor terminals lacking proper amenities. Accordingly, UTP set "improvement in mobility through traffic management measures" as one of its objectives (UTP implementation manual, 2007). The UTP unit in Kumasi was established in October 2008 following the passage of the Bye-laws in June 2008.

2.7 Metro Mass Transit (MMT) in Ghana

The MMT was established with a mission to provide an efficient urban mass transport system in Ghana through the use of buses. The vision was to build a dominant, reliable, efficient, safe and affordable yet an economically sustainable mass transit public bus company. However this has not been achieved due to the problems mentioned earlier.

MMT is owned jointly by the Government of Ghana (45%) and private owners (55%) comprising State Insurance Company (SIC), National Investment Bank (NIB), Ghana Oil Company Limited (GOIL), Agriculture Development Bank (ADB), Prudential Bank and Social Security and National Insuarnce Trust (SSNIT).

The operations of MMT began in October 2002 in Accra and in March the following year was started in Kumasi as well. Today their services have extended to all the regions in Ghana. The original mandate was to provide intra-city services but with the collapse of OSA, The demand for intra-city and inter-regional services arose and so the MMT added these to their services.

MMT at the moment has a fleet of buses made up of Yaxing, DAF, Neoplan VDL, VDL Jonckhere, VDL Dutch, Iveco and Tata. Total fleet size nationwide as at the end of 2008 was 851 (www.metromass.com) The yaxing buses are manufactured in China, and the Tata buses in India. The DAF Neoplan & VDL Neoplan buses are manufactured at the Neoplan factory in Kumasi.

Buses used for intra-city services are Yaxing, Iveco and VDL Neoplan.

Iveco Bus

Yaxing Bus

VDL Neoplan Bus

The operational management of MMT introduced the philosophy of 'Hit & Run' in its operations, i.e. buses are built to move and not to be parked. The target was to realize a maximum parking time of 5 minutes at every terminal in Ghana where passengers were to buy a ticket in advance and queue before a bus arrives. The Hit & Run system was to increase the frequency of all urban and rural services in order to optimize the customer satisfaction. This has however not been achieved due to the problems stated..

In addition, MMT started a pilot project for a bus rapid transit system in Accra in September 2005. This could not be sustained due to lack of enforcement and other operational issues.

2.8 Kumasi Road Network and MMT Routes

The road network in Kumasi can be described as consisting of a combination of radial and gridlike network. It consists of a ring road with the south eastern quadrant presently under construction.

The road network has been classified using international standards into 4 main classes namely Principal Arterial, Minor Arterial, Collector and Local roads (BCEOM and ACON, 2004). The classification was based on factors which include service function, traffic volume, flow characteristics, running speed and connections.

The MMT routes are all radial, beginning from the CBD specifically Kejetia which is the heart of the city.

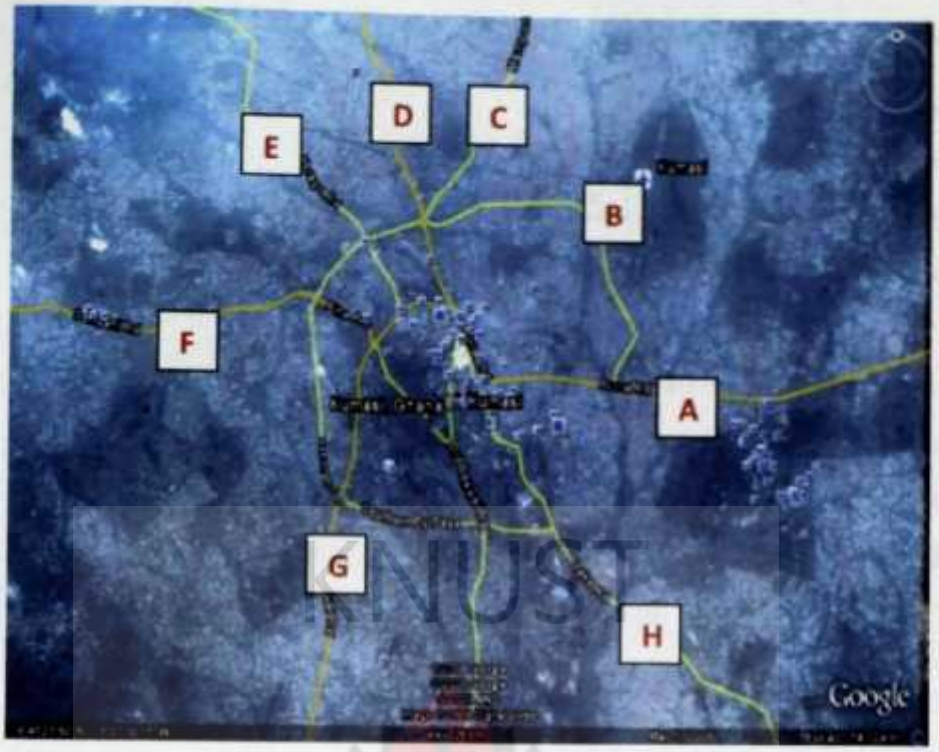


Figure 2: Map of Kumasi showing MMT bus routes

The corridors on which the MMT buses ply are:

A. 24th February road
B. Antoa road
C. Mampong road
D. Offinso road
E. Barekese road
F. Sunyani road
G. Obuasi road
H. Lake road

2.9 Travel Difficulties in Kumasi

Travel pattern in Kumasi is such that many people move to the central part of the city in the mornings and back to their respective homes in the evenings. The lateral development

has also made people to move from the sub-urban and peri-urban areas to the CBD to work, school, trade or for social activities.

The CBD also serves as a transit point with Kejetia terminal serving as a major point of interchange for travelers. This is attributed to the radial nature of the routes and lack of alternative routes to other destinations outside the Kumasi metropolis (Fofana, 2008).

According to Amo-Asamoah, 2008, the major difficulty in arriving at the final destination is the infrequent arrival of public transport due to congestion. On the Lake road for example, a distance of 6km which can be covered in 15 minutes during the off peak period is covered at close to an hour during the peak period. It was also realized that most people in the sub-urban and peri –urban areas arrive at the bus stands by means of "trotro" (49.4%), walking (35.2%) and by shared taxis (9.6%).

Asabre, 2008, also identified congestion as the major cause of travel difficulties which resulted in long queues at the bus stands and further resulting in long waiting times. In such situations the "trotros" do not run the full length of their journey and passengers would have to make their full journey in more than one trip, eventually paying more. During such times taxis also shift from shared mode to contractual mode.

It was identified that the use of low occupancy vehicles was the main cause of congestion on the roads and in all the studies it was recommended that the use of high occupancy vehicles be encouraged and a better public transport system be provided.

2.10 Present Operations of the MMT Bus Services in Kumasi

The operational parameters reviewed are presented below.

2.10.1 Ridership

From the public perception studies carried out by Swanzy-Donkor in 2006, the following observations were made.

Male and female patronage of the MMT service is 50.25% and 49.75% respectively. Age group is mostly 18-40 years which form the bulk of the active working group. This is followed by 6- 17 years of school going children and 41-60years respectively. The number of riders who are over 60 years was not much. This can be attributed to the fact that the buses do not have enough seats and most passengers have to stand through the journey and so are not attractive to the aged. It was also observed that majority of passengers were students (39.75%) followed by traders (23.5%) and artisans (24%) and civil servants (12.75%).

A similar study by Abdul-Wahabi, 2003, however revealed that majority of the riders were traders made of small scale business owners and market men and women.

Swanzy-Donkor identified that 80.75% of riders preferred boarding "trotro" to MMT buses. The trip purposes identified were mostly to work and school. On the number of motorized trips taken to complete a journey, averagely, 64 %, 33% and 3% take one, two and more than two trips respectively. Almost all the occupational groups use the service more than four times a week which indicates a high frequency of usage.

Passengers complained of long waiting times, poor ventilation, lack of adequate number of seats, unavailability of MMT service along their routes, unreliability and irregularity of the service and frequent bus stops.

Fares charged by the MMT service are lower than "trotros" and so passengers were generally satisfied with the fares.

2.10.2 Waiting time

Swanzy-Donkor, 2006, identified that almost 50% of passengers had to wait 15-30minutes at bus stops before a bus arrives. 28% wait for less than 15 minutes and the rest wait for more than 30 minutes.

At the Kejetia terminal average waiting time for a bus is 40-50 minutes (Abdul-Wahabi, 2003).

2.10.3 Distance between stops

On the Mampong road, for a route length of 9700m from Kejetia to Ahwiaa, the distance between stops varied from 100m to 950m. The average distance was 485m. That for the Lake road, a route length of 14700m from Kejetia to Aputuogya, varied between 300m to 2200m. In the dense urban areas, distances were observed to be shorter and longer in the sparsely located settlements. Some passengers were seen alighting when bus is caught up in traffic (Abdul-Wahabi, 2003). On the Barekese and Obuasi route some distances were as close as 50m and 100m apart respectively (Seshie, 2003).

2.10.4 Travel time

The round trip travel time excluding dwell times thus time spent at stops to serve passengers is about an hour for the Mampong route and one and half hours for the Lake road. On the average an individual takes 7-9secs and 4-6secs to board and alight from the bus respectively. The longer time in boarding is attributed to time used in getting ticket. The section from Kejetia to New Road Junction on the Mampong route is mostly congested during the peak period. On the Lake road congestion is experienced from Kejetia to Agogo station (Abdul-Wahabi, 2003). Average travel time on the routes is 75mins (max) and 37minutes (BCEOM and ACON, 2004). This however depends on the time of travel.

2.10.5 Journey speed

The average speed during the peak period is 17kmph for the Mampong route and 22kmph for the Lake road. Within about 2km radius of the CBD speeds are less than 10kmph (Abdul-Wahabi, 2003). On the Barekese route speeds were as low as 3.6kmph. (Seshie, 2003). A study by BCEOM and ACON, 2004 on all the routes revealed a maximum and minimum journey speed of 20.5kmph and 9.7kmph respectively.

2.10.6 Load Factors

Load factors varied from less than 1 during the off peak to greater than 1 during the peak period in the densely populated urban areas. Since the routes are not strictly in the urban areas, load factors in the peri-urban areas were most often less than 1 (Seshie, 2003). Generally an average minimum and maximum load factor of 0.62 and 0.96 respectively was recorded by BCEOM and ACON, 2004.

2.11 Strategies to Improve Operations

Urban transport infrastructure is expensive as such expansion of the infrastructure can not be continued as the demand increases especially in developing countries. Alternative solutions thus need to be employed to solve urban transportation problems and enhance their operations. Several strategies have been employed to improve the performance of bus operations in a number of developing countries and are discussed below.

2.11.1 Busways

Busways are segregated traffic lanes for the exclusive use of buses. They provide physical separation from other traffic by use of barriers such as medians, high kerbs or studs. Sometimes fences are also provided to prevent pedestrians from crossing the road. Busways may be located in the middle of the carriageway or next to kerbs. Countries that have adopted busways include Brazil, Turkey, Peru and Cote d'Ivoire.

The performance of busway transit varies from place to place and depends on a large number of factors namely the extent to which overtaking is permitted, the bus stop arrangements, the capacity of the buses, special operational measures such as the ordering of buses and the proportion of boarding and alighting passengers (Armstrong - White, 1993).

A trunk or feeder system can be operated to complement the operations on the busways where passengers from the surrounding areas are brought to busway terminals for transfer onto larger buses on the busways as practiced in Curitiba, Brazil. Busways are generally for large buses and minibuses and paratransit buses are excluded from using it. In Sao Paolo, Brazil, busways have been successful due to the overtaking lanes provided at almost all the bus stops minimizing delays and enabling semi express bus services to operate. A tow truck has also been provided for breakdowns making the bus way free at all times for moving vehicles.

2.11.2 Bus lanes

A bus lane or bus only lane is a lane restricted to buses, and generally used to speed up public transport otherwise held up by traffic congestion. Often taxis and high occupancy vehicles or motorcycles and even bicycles may use bus lanes as well, though these uses can be controversial since they can reduce the capacity of the bus lane for its main function. However, bus only lanes are a special form of bus lanes restricted to only buses. www.rta.nsw.gov.au.

Bus lanes do not have physical separation from other traffic like busways. Bus lanes give priority to buses and save journey time where roads are congested with other traffic. A bus lane is not necessarily very long, as it may only be used to bypass a single congestion point such as an intersection. Bus lanes are normally created when the road in question is both likely to be congested and heavily traveled by bus routes. Entire roads can be designated as bus lanes such as Oxford Street in London or Fulton Street in New York City, allowing buses, taxis and delivery vehicles only. A contra-flow bus lane can allow buses to travel in the opposite direction to other vehicles. Some bus lanes operate at certain times of the day only, usually during rush hour, allowing all vehicles at other times, and it is common to have bus lanes in only one direction, such as for the main direction of the morning rush hour traffic, with the buses using normal lanes in the other direction. Bus lanes may have separate sets of traffic signals, to allow priority at intersections.

The first bus lane was created in Chicago in 1939. The first bus lanes in Europe were established in Hamburg, Germany in 1962. Other countries have since implemented this for their bus operations (Wikipedia).

Arasan and Vedagiri, 2008 have identified that the justification for provision of bus lanes is to check for the number of people using the road space instead of number of vehicles using it. In their study, 'Provision of Exclusive lanes for Buses on Urban Roads', they identified that for traffic flow at LOS C, bus travellers constitute 66% but use only 26% of road space and all other travellers constitute 34% but use 76% of road space. For traffic at full capacity, bus travellers constitute 63% but use only 26% of road space and all other travellers constitute 37% but use 74% of road space. Arasan and Vedagiri therefore concluded that provision of bus lanes can ensure a max LOS of C on road ways for other motor vehicles and the mean running speed on a bus lane rising up to 65km/h.

2.11.3 Use of high Occupancy Vehicles

High Occupancy Vehicle (HOV) is a vehicle that can carry two or more persons. These vehicles sometimes have exclusive traffic lanes called "HOV lanes," "busways," "transitways" or "commuter lanes" (Public Transport Fact book, 2007).

However, in the context of this study, a HOV is in reference to a bus with a minimum of 23 passengers.

The use of high occupancy vehicles is to reduce the volume of low occupancy vehicles and subsequently reducing congestion. By so doing more passenger trips can be made to move more passengers rather than move vehicles.

Traffic congestion is a non linear function, meaning that a small reduction in urban peak traffic volume can cause a proportionally larger reduction in delay. It is estimated that a 5% reduction in traffic volumes on a congested road can cause a 10 – 30% increase in average vehicle speeds (Nair and Kumar, 2008).

According to Khisty and Kent Lall (2006), any reduction in traffic volume greater than 10% can cause an improvement in the LOS of a road.

Table 2: Capacity of an Urban bus

		Design Capacity		
	type of bus	seated	total	typical peak period crash loading
1	minibus	12	20	40
2	small bus	20	30	50
3	adapted truck	20	35	45
4	medium bus(standard bus)	40	80	105
5	large single deck bus	50	100	125
6	double deck bus	80	120	150
7	large double deck bus	80	170	200
8	articulated bus	55	120	150
9	large articulated bus	55	170	210

Source: world bank studies (Alan Armstrong-White, 1993).

Table 2 above shows the various capacities of urban bus that can be used for public transport operations.

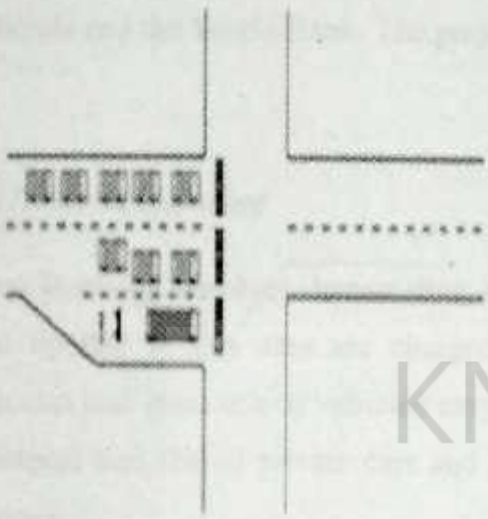
2.11.4 Signal Prior ity

Signal priority is giving priority to buses at intersections where they are allowed to cross an intersection without being held up in the red phase. It involves the extension of the green time or actuation of the green time upon detection of an approaching bus (Ghosh and Dhingra, 2008). This has been implemented successfully in Bangkok, Thailand and many European cities, including Zurich, Switzerland and Finland.

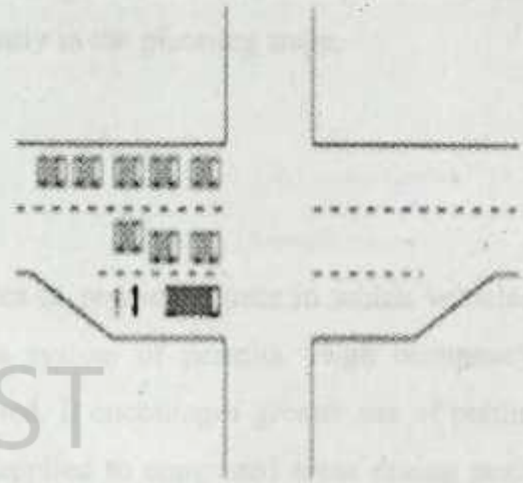
2.11.5 Queue Jump

This is the provision of an additional travel lane known as the queue jump lane on the approach to a signalized intersection which is often restricted to transit vehicles only, although some variations may permit bicycles, mopeds, and/or motorcycles. The additional lane is generally accompanied by a signal which provides a phase specifically for vehicles within the lane. Vehicles in the queue jump lane get a "head-start" over other queued vehicles. Sometimes the lane is extended across the intersection so that transit

vehicles can therefore merge into the regular travel lanes immediately beyond the signal. (Wikipedia).



Queue jump lane with a designated signal



Queue jump lane continued through an intersection

2.11.6 Bus rapid Transit (BRT)

BRT is the provision of dedicated bus lanes operating at a higher quality than ordinary bus lane with well constructed stations. There are three forms of BRT as described by Ghosh and Dhingra, 2008. The real BRT has segregated bus ways with higher quality stations and pre board fare payment. Full BRT has the metro quality service with closed higher quality stations, pre board fare payment, frequent and rapid service with modern vehicles. The third kind of BRT, known as BRT Lite has some form of bus priority but not fully segregated bus ways and with higher quality shelters.

The BRT in Bogota, Columbia is called Transmilenio. It was started in December 2000, has two lanes in each direction located in the median and operates ordinary and express services with high speeds and few stops. In Lagos, Nigeria the BRT Lite was introduced in March 2008 and had since helped in public transportation services (Wikipedia). BRT is practiced in Curitiba, Porto Alegre and Sao Paolo in Brazil, Quito in Ecuador (Francis Kuhn) and other cities including Leon, Mexico city, Ottawa, Los Angeles and Beijing (Ghosh and Dhingra ,2008)

In Ghana, a BRT pilot project is proposed to be developed for the city of Accra. This follows a study (Nuworsoo, 2006) into the development of a full concept for a city-wide rapid transit system for Accra, the capital of Ghana which was adopted by Government officials and the World Bank. The project is currently in the planning stage.

2.11.7 Ar ea licensing

Area licensing involves demarcating a certain area as restricted zone in which vehicles that operate in this area are charged through a system of permits. High occupancy vehicles and commercial vehicles may be exempted. It encourages greater use of public transport and shared private cars and is usually applied to congested areas during peak periods.

Area licensing has been practiced successfully in Singapore and London where it is known as "congestion pricing scheme" (Armstrong-White, 1993).

2.11.8 Road pricing and user restraints

This involves the use of road pricing and car user restraints as a means of reducing congestion and to improve in particular conditions for public transport (Armstrong-White, 1993).

2.11.9 Policy formulat ion and Enforcement

The introduction of certain strategies requires the formulation of policies to compliment its implementation. Governments need to formulate policies and be committed to them to ensure that the strategies work. The various stakeholders in the transportation sector should be equipped to enforce the policies.

2.11.10 Private sector participation

Studies by the World Bank indicate that the private sector accounts for more than 75% of all bus trips in developing countries. The costs of running publicly owned bus services is almost double that of privately owned services operating on same routes under same conditions. Although the fares of private operators are generally higher than public operators they are still able to make modest profits (Armstrong-White, 1993). The performance indicators determined for public and private bus operators in the same city indicated that the private sector performed better.

Table 3: Performance of public and private bus operators

Bus operator performance indicators(ranges)	**public**	**private**
Average fleet availability (%)	47-85	80-89
Passengers per bus daily	1200-2200	200-2900
Passengers per km operated	7.6-10.1	1.2-12.1
Daily km per bus operated	160-220	170-240
Staff per bus operated	5.8-13.5	1.0-3.7
Load factor	0.3-0.6	0.6-0.9
Profitability (revenue:cost)	0.6-1.2	0.9-3.6

Source: TRL Research report 294 (Alan Armstrong-White, 1993).

CHAPTER THREE

3.0 DATA COLLECTION

3.1 Data Collection

3.1.1 Selection of Study Routes

There are eight (8) major routes on which the MMT operates, two of which are single carriageway roads. These are also the main corridors for passenger movement into and out of the city. Three of these routes were selected for the data collection. A study by BCEOM/ACON, 2004, indicates that these routes are highly congested and fall within the first five congested routes. Physical characteristics such as number of travel lanes, type of intersection control device and extent of road side activity was also considered in the selection. The selected routes are;

1. **24th February Road (A).** This road, also known as the Accra road, begins from the Asafo Interchange through KNUST junction to Ejisu. It is a dual carriage road. There are six (6) signalised intersections and five (5) ro undabouts over a distance of 21.1km. Pedestrian activities along the route are controlled due to the raised shoulders. Hawking activities are very severe at the signalized intersections where hawkers take advantage of the red phase to ply their wares. Major bottlenecks along the route are located at Amakom, Oforikrom and KNUST junction where "trotros" and taxis park on the shoulders and in the laybyes to wait for passengers. Their activities spill over onto the carriageway thereby causing a lot of inconvenience and unsafe conditions for other motorists.

2. **Mampong R oad (B).** This is a single carri age road with all its intersections being priority controlled. It begins from Kejetia, the central part of Kumasi, through Tafo to Mamponteng, a length of 12.4km. The route has the biggest roundabout in Kumasi, the Suame roundabout. All approaches to the roundabout are dual carriaged for their entire lengths except for the Mampong road which has only 200m of the approach length

dualised. There is heavy pedestrian activity along this route. This includes the sale of vehicles and their parts and other commercial activities. The Suame roundabout is not able to accommodate the ever increasing traffic flow thus making it difficult to move through. The Tafo market and station are also located along this route.

3. **Lake Road (C).** This is a single carriageway from Asafo in the CBD to Chirapatre. The intersections on this route are all priority controlled but for two of which are signalized. Pedestrian activity along this route can be said to be of medium intensity. The Atonsu Agogo Market and station are located along this route. These together with the Gyinyase, Kaase and Millenium plaza intersections are major bottlenecks on the route.

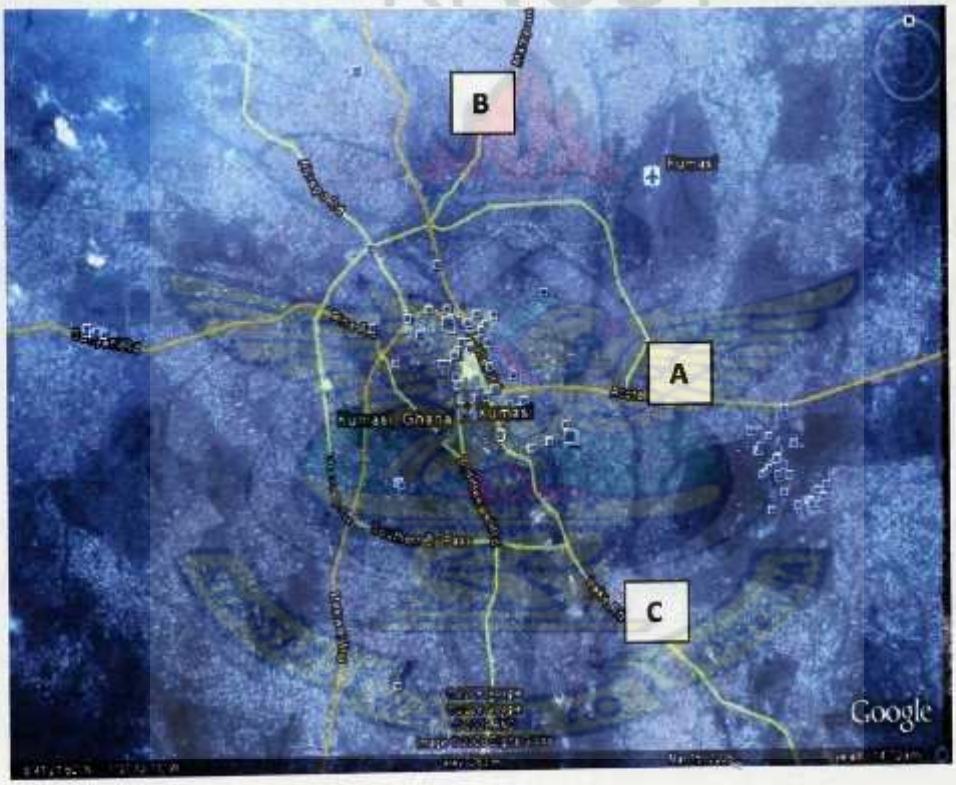


Figure 3: Map of Kumasi showing selected routes for the study

3.1.2 Manual Classified Counts

Traffic volume counts were conducted on the three selected routes. Vehicles were classified according to the types stipulated in the Ghana Highway Authority (GHA) design guide. The categories used were car, taxi, pickup/vans/jeeps, small buses (mainly

"trotros"), medium/large buses and trucks. Counts were done for 12hours from 6am to 6pm on a Wednesday at designated traffic count sites of the Department of Urban roads. The study was done manually by tallying the various classes of vehicles as they passed. The Classified count was done to determine the percentages of each vehicle type that use the routes.

3.1.3 In-Vehicle Bus Studies

In – vehicle bus studies were done by boarding the MMT buses to observe loading patterns which involved boarding and alighting characteristics and identify the location of stops and actual number of stops along the route. The observer sat in the bus to observe these characteristics from origin to destination for each route. Travel time and delay studies were also conducted to identify the locations of bottlenecks that cause delays on the routes. This was done with an observer sitting in a vehicle and noting the congested areas, the cause of delay and the time taken to traverse such sections of the roadway.

3.1.4 Observations at Terminal and Road Side

Observations were also done at the origin points to observe the terminal conditions and how passengers got their tickets and got on board the bus.

3.1.5 Interview of MMT

A structured interview with the management of MMT was also undertaken. The purpose was to gather information on their operations, maintenance systems in place and challenges that they face in their day to day operations. Two persons from the MMT were interviewed. These were the head of the traffic section and the head of the intra-city operations.

CHAPTER FOUR

4.0 ANALYSIS AND DISCUSSION OF RESULTS

4.1 Operational Characteristics

The in- vehicle bus studies revealed that at the beginning of the journey passengers pay for the trip and are issued with their tickets before they board. Passengers that were picked along the route either paid before boarding if they are many or paid on board if they are a few since they could be identified easily in the bus.

It was also noted that from the CBD towards the outskirts, passengers boarding were significant within the CBD area, with a few passengers alighting. However, most passengers were seen alighting at the later stops close to the final destination point.

4.2 Classified Master Counts

The results of the classified master counts (see details in Appendix One) which were done to determine the proportions of the various categories of vehicles on the roads revealed the following.

4.2.1 24th February Road

Table 4: 12 hour Classified Volume for 24th February road

Vehicle type	East bound to KNUST(Veh/day)	West bound to Adum(Veh/day)	total 2 way volume(Veh/day)	% of total
Car	3654	3833	7487	**23.1**
Taxi	5903	6186	12089	**37.3**
PU/Vans/jeeps	1143	1191	2334	**7.2**
Small Bus ("trotros")	3843	3968	7811	**24.1**
Medium/Large Bus	622	776	1398	**4.3**
Trucks	594	691	1285	**4.0**
Total	15759	16645	32404	**100.0**
Directional split (%)	48.6	51.4		

Table 9 above shows the 12hour classified volume for the 24th February road. It can be seen that taxis (37.3%) constitute majority of the vehicles that are found on the road. This is followed by "trotros" (24.1%) and cars (23.1%). Taxis and "trotros" together, which are used for public transport, constitute about 60% of the vehicle fleet. The large buses which are intended to carry a lot of people however are only 4.3% of the total volume of vehicles on this particular route. It can be said that the low occupancy vehicles which includes the taxis and cars are in the majority and this contributes greatly to the congestion experienced on the road.

Table 5: Average Vehicle Occupancy values

Type of Vehicle	Occupancy Value
car	2.1
taxi	3.5
pick-up	3.7
mini/small bus	12.3
medium/large bus	23.8
Truck	3.2

Source: BCEOM and ACON 2004

The average vehicle occupancy values (Table 5) were adopted from the BCEOM and ACON report 2004 and used to estimate the number of passengers carried by each type of vehicle.

Figure 4: Chart showing Percentage of type of vehicle per hour (4a) and Percentage of passengers carried per vehicle per hour (4b) on 24th February road

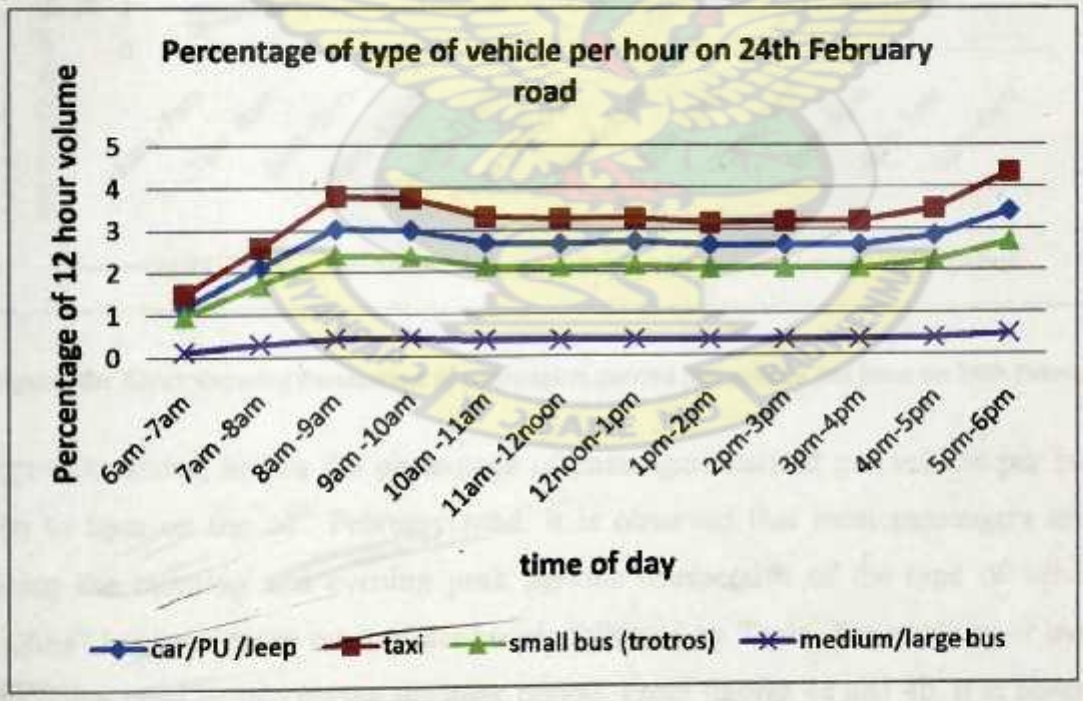


Figure 4a: Chart showing Percentage of type of vehicle per hour on 24th February road

Figure 4a shows the percentage of vehicle type per hour between 6am and 6pm on the 24th February road. It shows the trend of the vehicles on the road throughout the day. It is observed that generally the vehicles start peaking between 7:00am to 10:00am and from 3:00pm to 6:00 pm. These times are actually the morning and evening peak periods for Kumasi where there is high demand for vehicles. The volumes of low occupancy vehicles, cars and taxis especially remain high throughout the day and this contributes immensely to the level of congestion on the road. The volumes of medium and large buses also remain fairly constant throughout the day though insignificant.

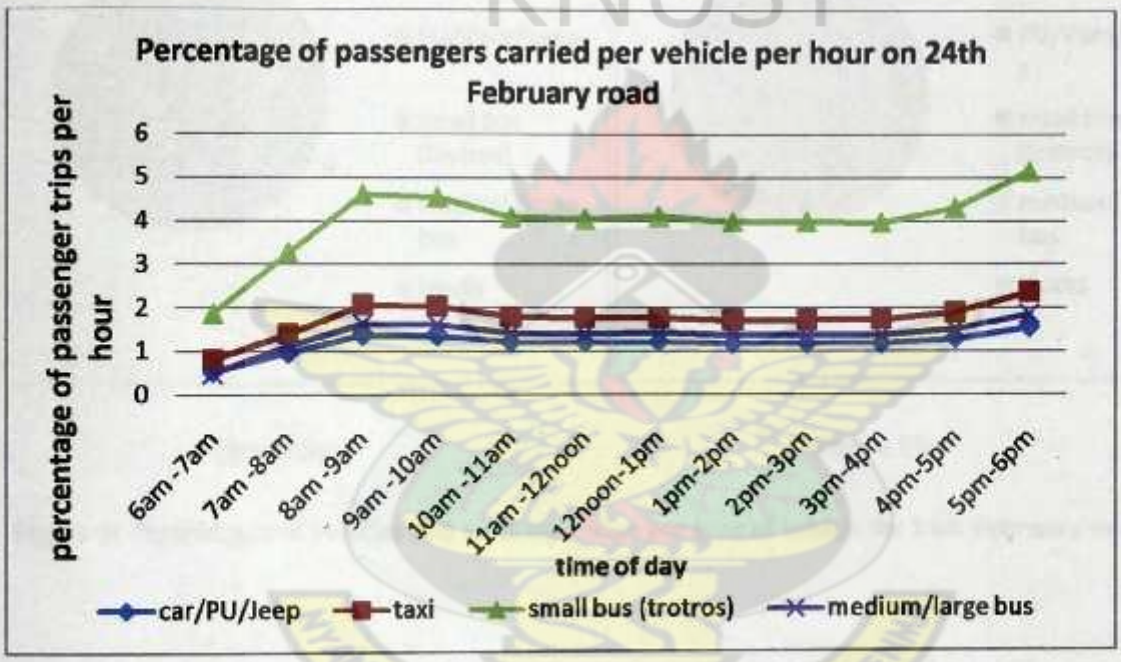


Figure 4b: Chart showing Percentage of passengers carried per vehicle per hour on 24th February road

Figure 4b above, shows the percentage of passengers carried per vehicle per hour from 6am to 6pm on the 24th February road. It is observed that most passengers are moved during the morning and evening peak periods irrespective of the type of vehicle. The "trotros" however move most of the people followed by Taxis. The medium or large buses also move most people during the peak period. From figures 4a and 4b, it is observed that the trend of volume of vehicles and passengers carried remains the same with highest

volumes recorded during the peak periods. The issue of concern however is to move more people rather than vehicles during these peak periods.

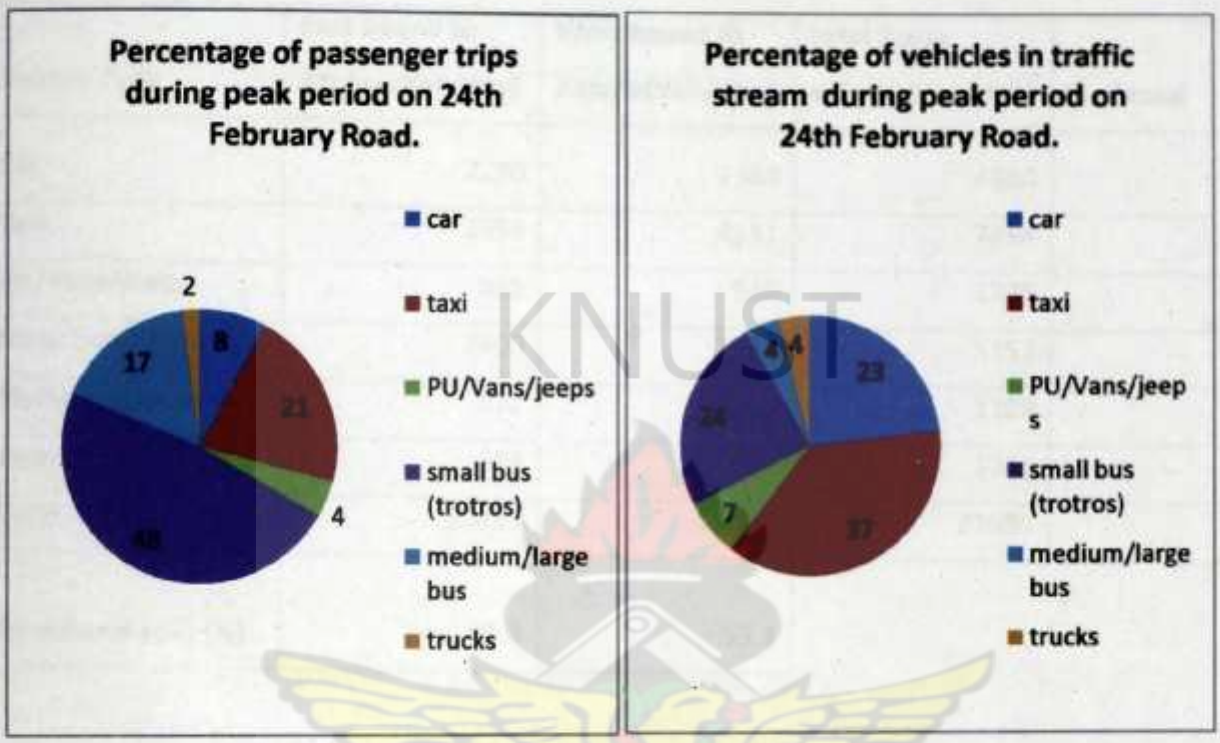


Figure 5a Figure 5b

Figure 5: Percentages of vehicles and passenger trips per type of vehicle for 24th February road

From the figures above, cars and taxis constitute 23% and 37% of the traffic stream and carry about 8% and 21% of passengers per hour respectively. "Trotros" constitute 24% of vehicles in the traffic stream and carry close to 50% of the passengers. The large buses, to which category the MMT belongs are only 4% of vehicles but carry 17% of persons per hour. It can be seen that the large buses carry passengers as much as four times their volume in the traffic stream while "trotros" carry about twice their composition in the traffic stream. One can deduce that if larger buses are used instead of the low occupancy vehicles then more people will be moved and this will significantly reduce the number of low occupancy vehicles thereby reducing congestion.

4.2.2 Mampong Road

Table 6: 12 hour Classified Volume for Mampong road

Vehicle Type	East bound to Atonsu(Veh/day)	West bound to Kejetia(Veh/day)	total 2 way volume(Veh/day)	% of total
Car	2296	2584	4880	**18.4**
Taxi	3653	4111	7764	**25.3**
PU/Vans/jeeps	835	940	1775	**7.0**
Small Bus ("trotros")	2400	2757	5157	**34.7**
Medium/Large Bus	522	587	1109	**8.8**
Trucks	584	662	1246	**5.8**
Total	10290	11642	21931	**100.0**
Directional split (%)	**46.9**	**53.1**		

Table 6 above shows the 12hour classified volume for the Mampong road. On this road, "trotros" (35%) rather constitute majority of the vehicles. This can be attributed to the surrounding villages along this route from where people commute to Kumasi daily. The "trotros" are followed by taxis (25%) and cars (18%). Public transport vehicles, mostly taxis and "trotros" together, constitute about 60% of the vehicle fleet. The medium and large buses are 9% of the vehicle fleet and these are mostly 23 seater buses which are popularly called "207" buses. The "207" buses are the most common type of buses that are used to transport people from surrounding villages to Kumasi.

Figure 6: Chart showing Percentage of type of vehicle per hour (6a) and Percentage of passengers carried per vehicle per hour (6b) on Mampong road

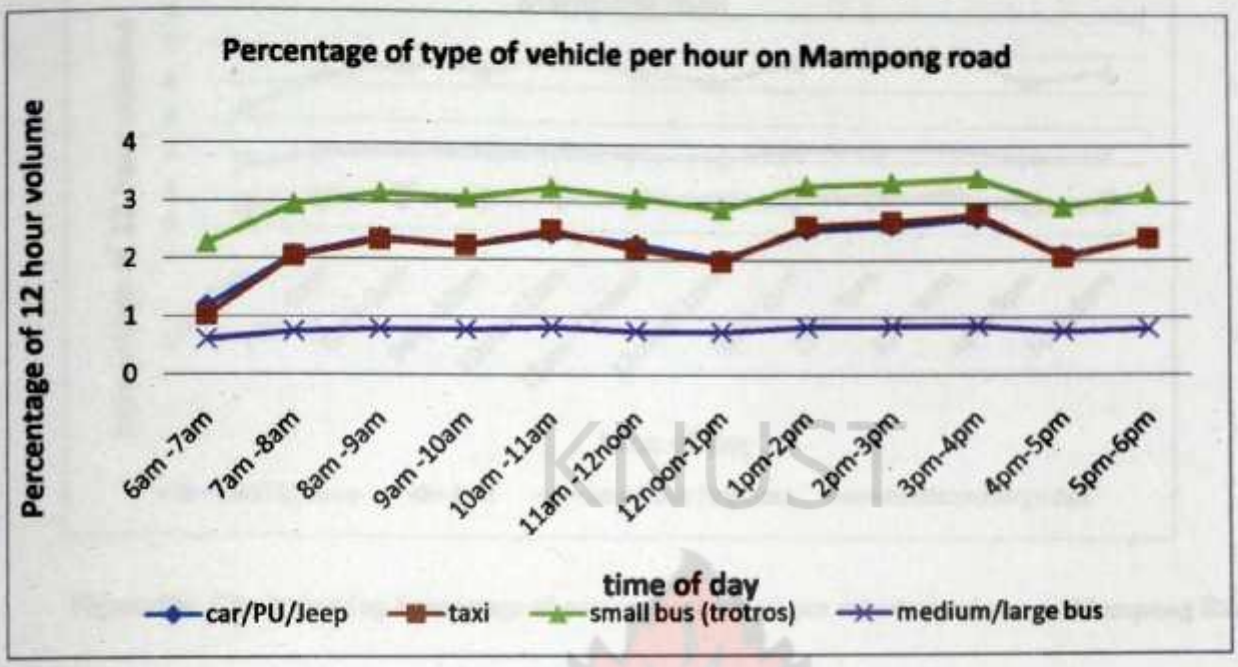


Figure 6a: Chart showing Percentage of type of vehicle per hour on Mampong road

The figure above shows the percentage of particular types of vehicle at particular times throughout the day. On this route the volumes of the medium/large buses which are mainly the 207 buses remain fairly constant throughout the day. This is due to the fact that at every point in time people from surrounding villages especially traders are being brought in to Kumasi or returning to their villages. The general trend of the morning peak period which is 7:00am to 10:00am is also observed on this route. However, the evening peak period starts earlier in the afternoon at 1pm than the usual 3:00pm.

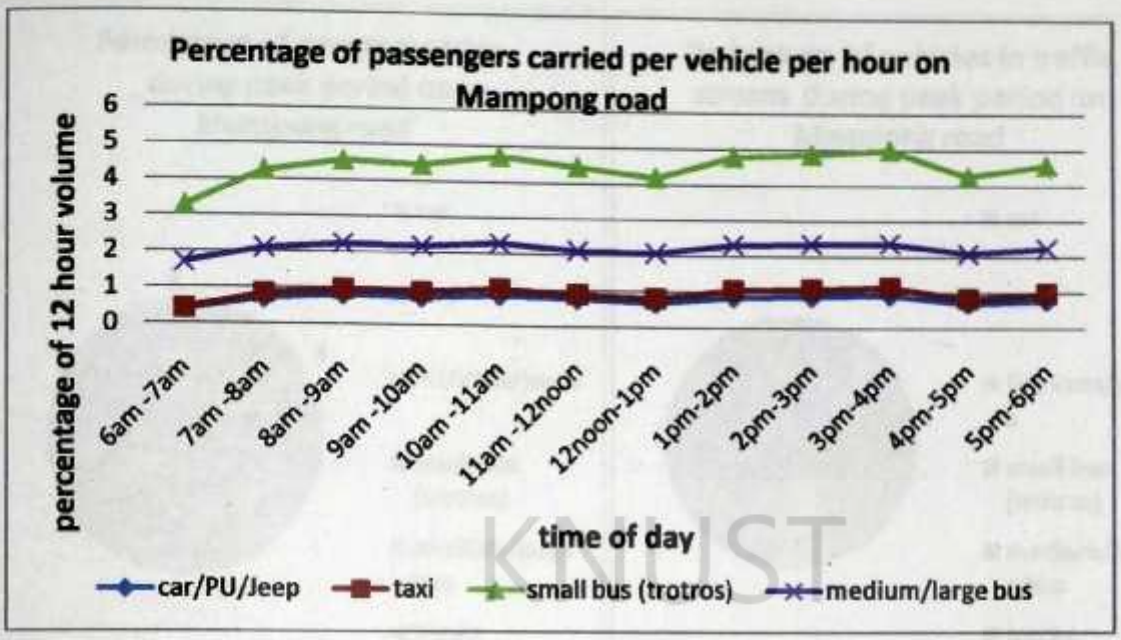


Figure 6b: Chart showing Percentage of passengers carried per vehicle per hour on Mampong Road

Figure 6b above, shows the percentage of passengers carried per vehicle per hour from 6am to 6pm on the Mampong road. It is observed that the "trotros" carry most passengers followed by medium or large buses. The taxis and cars carry almost same number of passengers. It is also observed that there is no distinctive peak period on this route. People move on the route virtually throughout the day.

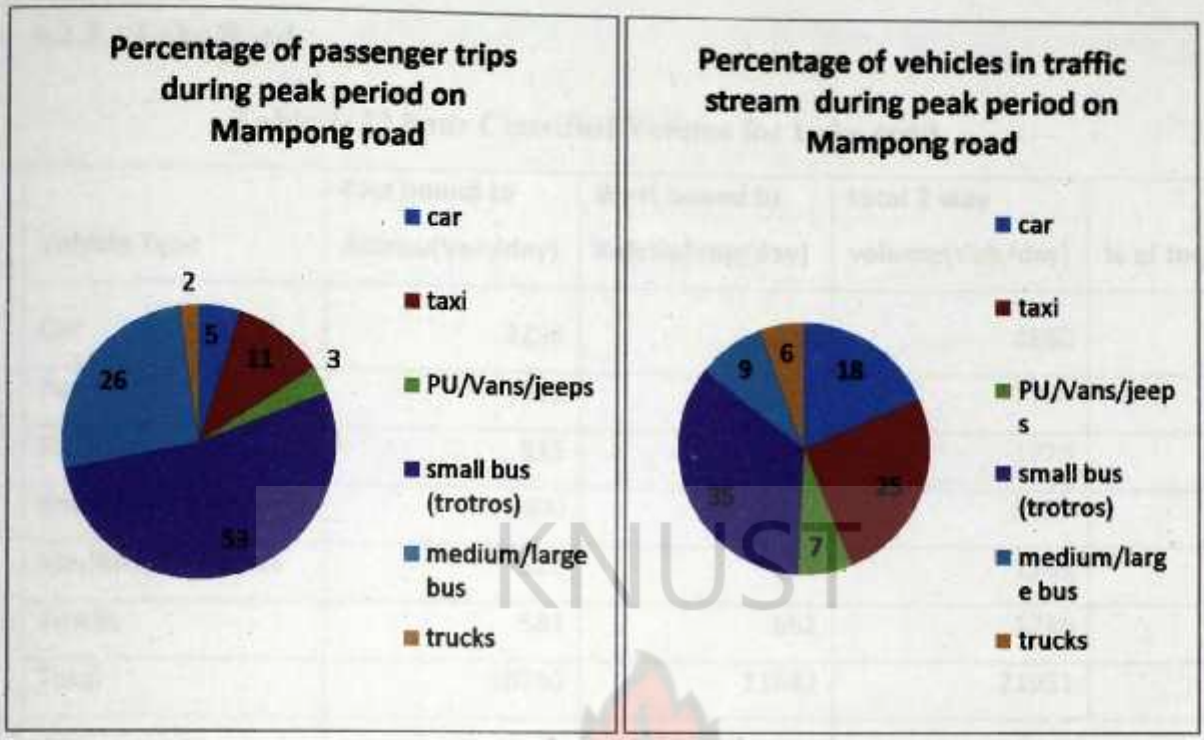


Figure 7a Figure 7b

Figure 7: Percentages of vehicles and passenger trips per type of vehicle for Mampong road

It can be observed from the figures above that, the "trotros" which constitute 35% of the vehicles carry 53% of persons per hour. The medium/large buses which constitute only 9% of vehicles carry as much as 26% of the people. The low occupancy vehicles mostly cars and taxis which are very significant in the vehicle fleet and contribute to congestion on the roads carry far less number of people. It can be inferred that if large buses are used then more passengers rather than cars will be moved.

4.2.3 Lake Road

Table 7: 12 hour Classified Volume for Lake road

Vehicle Type	East bound to Atonsu(Veh/day)	West bound to Kejetia(Veh/day)	total 2 way volume(Veh/day)	% of total
Car	2296	2584	4880	**22.3**
Taxi	3653	4111	7764	**35.4**
PU/Vans/jeeps	835	940	1775	**8.0**
Small Bus ("trotros")	2400	2757	5157	**23.5**
Medium/Large Bus	522	587	1109	**5.1**
Trucks	584	662	1246	**5.7**
Total	10290	11642	21931	**100.0**
Directional split (%)	**46.9**	**53.1**		

Table 7 above shows the 12hour classified volume for the Lake road. It can be seen that taxis (35.4%) constitute majority of the vehicles that are found on this road. This is followed by "trotros" (23.5%) and cars (22.3%). Taxis and "trotros" together, which are mostly used for public transport, constitute about 60% of the vehicle fleet. The large buses which carry a lot of people however are only 5.1% of the total volume of vehicles on this particular route. It can be said that the low occupancy vehicles which includes the taxis and cars are in the majority and this contributes to the congestion experienced on the road.

Figure 8: Chart showing Percentage of type of vehicle per hour (8a) and Percentage of passengers carried per vehicle per hour (8b) on Lake road

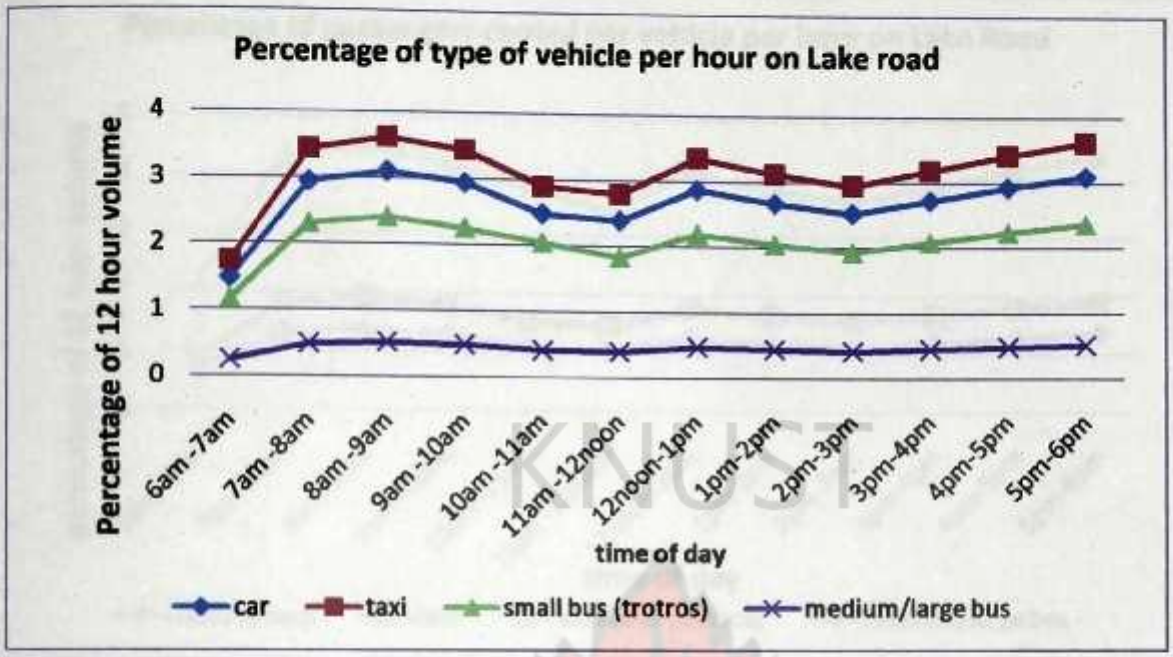
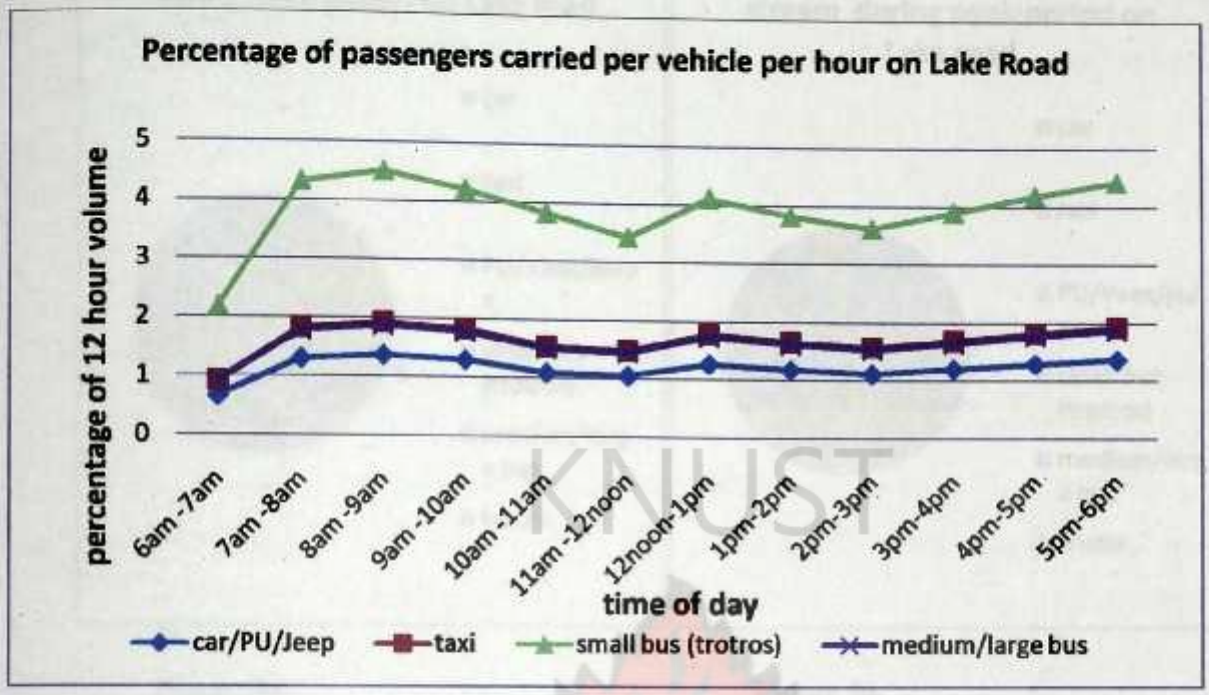


Figure 8a: Chart showing Percentage of type of vehicle per hour on Lake Road

The figure above shows the percentage of particular types of vehicle at a specific time throughout the day. It is observed that there are three peak periods on this route; a morning peak of 7:00am to 10:00am, an afternoon peak of 12noon to 2pm and an evening peak of 3:00pm to 6:00 pm. The volumes of low occupancy vehicles, cars and taxis especially remain high throughout the day and this contributes immensely to the level of congestion on the road. The volumes of medium and large buses also remain fairly constant throughout the day though insignificant.

Figure 8b: Chart showing Percentage of passengers carried per vehicle per hour on Lake Road



The percentage of passengers carried per vehicle per hour from 6am to 6pm on the Lake road is shown in figure 8b above. It is observed that the "trotros" carry most passengers. The taxis and medium / large buses carry almost same number of passengers. It is also observed that most passengers are moved during all the three peak periods.

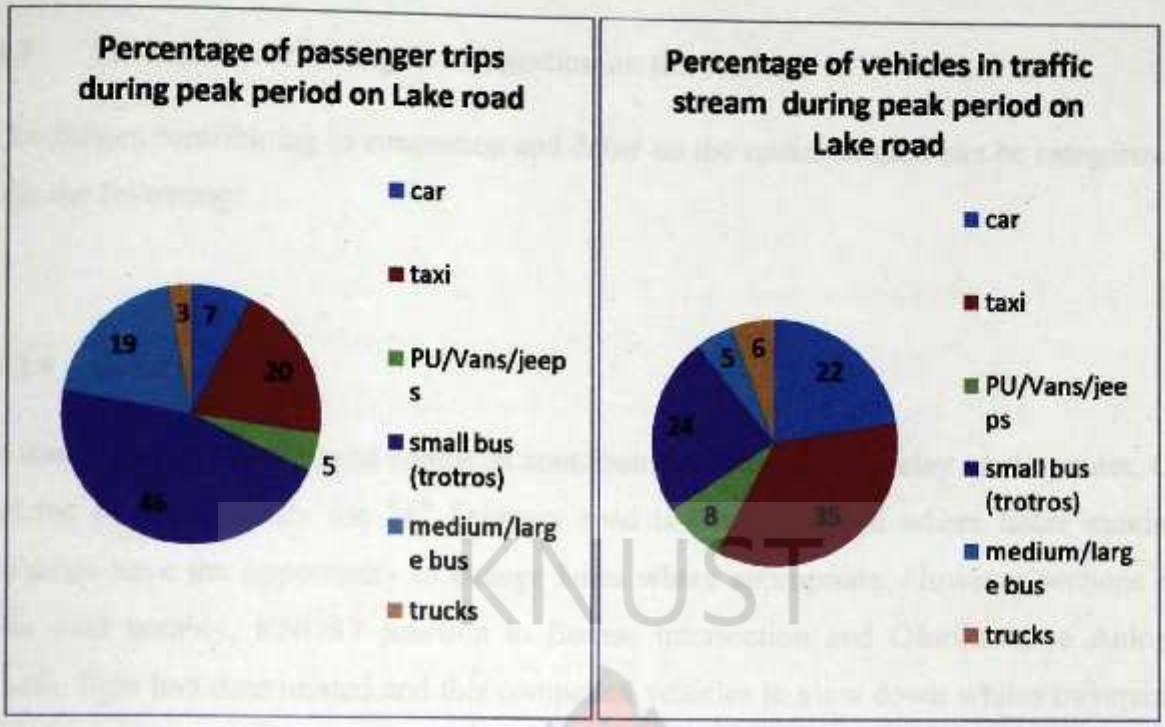


Figure 9a

Figure 9b

Figure 9: Percentages of vehicles and passenger trips per type of vehicle for Lake Road

Figure 9 indicate the percentage of the various types of vehicles in the fleet as against the percentage of persons carried by that particular vehicle. The situation is not too different from what has been observed on the other two routes. Cars and taxis which constitute most of the vehicles in the traffic stream, 22% and 35% respectively, carry only about 7% and 20% of passengers per hour. "Trotros" constitute 24% of vehicles in the traffic stream and carry 46% of the passengers. The large buses, in which category the MMT belongs to are only 5% of vehicles but carry almost 19% of persons per hour. Once again, the large buses carry passengers as much as four times their volume in the traffic stream while "trotros" carry about twice their composition in the traffic stream. One can deduce that if larger buses are used instead of the low occupancy vehicles then more people will be moved and this will significantly reduce the number of low occupancy vehicles thereby reducing congestion.

4.3 Factors Contributing to Congestion on the Routes

The factors contributing to congestion and delay on the routes studied can be categorized into the following:

4.3.1 Road Condition

It was observed that the road condition contributed to some of the delay on the routes. Of all the bus routes only the 24th February road is dual carriaged where faster moving vehicles have the opportunity to change lanes where appropriate. However sections of this road notably, KNUST junction to Bomso intersection and Oforikrom to Anloga traffic light had deteriorated and this compelled vehicles to slow down whiles traversing these sections of the road way. The deteriorated sections had ruts, depressions and potholes all along the surface and this caused a lot of inconvenience to motorists as well.

All other routes are single carriageways. The Mampong road however has about 1.5km of it dualised. This dualised section is at the beginning of the route which is from Adehyeman through Suame roundabout to Wesley College. Beyond this point, the shoulders of the single carriaged section have broken off on both sides. This situation compelled public transport vehicles to stop virtually on the carriageway to service passengers causing delays to other motorists.

The Lake road is also a single carriageway. Again the beginning of this road, about 1.6km, from the Central Market to Asafo Cement roundabout is a dual carriageway. There is also a short section of about 60m approaching the Kaase intersection which is dualised. All other sections of the road are single carriage which is unable to carry the traffic volume on the road.

All the three routes on which the studies were done have exceeded their capacity as recorded by BCEOM and ACON 2004.

4.3.2 Intersection Control Devices (ICDs)

Intersections which are priority controlled with stop signs were significant bottleneck areas along the routes.

On the 24th February road, the Susuanso junction, a Tee intersection, is one of such bottleneck intersections. During the morning peak especially, most motorists from Ejisu end heading towards the CBD use the Bomso route as a bypass to cut off traffic. By so doing they have to cross vehicles heading towards KNUST in order to join the main road. This causes a lot of delays and unsafe conditions at the intersection.

All other intersections on the 24th February road are either signalized or controlled by a roundabout. The roundabouts seem to be controlling traffic effectively as no delays were experienced at such places. Long queues were however seen at the signalized intersections especially the Anloga and Amakom Traffic Signals. This can be attributed to the timing of the signals. The volumes at the approaches have changed and this is not reflected in the timing hence the delays experienced.

On the Mampong road, all the intersections along the route are Tees except for one, the Suame roundabout. The intersections that caused delays to motorists are the New Road junction and Tafo Hospital junction. Drivers from the minor roads did not follow the priority rules. They cross oncoming vehicles unnecessarily thereby blocking through traffic and causing delays at such sections.

The Lake road consists of two (2) signalized and more than ten (10) priority intersections. The signalized junctions are at Asafo market and texas junction. The Asafo market signal is within the dualised section of the route. Enquiries at the Department of Urban Roads revealed that the Asafo market signal is new with adequate timing and able to manage the traffic. The Texas junction signal has on old controller which trips off very often and so does not function well. At the time of the study, the signal was not functioning and drivers from Hudson road (the minor road) were seen forcing their way into the moving stream.

Other problem areas identified on the Lake road are the Kaasc, Ahinsan Loop and Gyinyase intersections. The Kaase junction is a cross intersecton. The dualised approaches from the Lake road, about 60m in length merge into a single lane and this causes a back up queue thereby causing delay to motorists. The Ahinsan loop and Gyinyase intersections, both tees are about 250m apart. Vehicles from the CBD heading towards Atonsu use the Ahinsan loop as a bypass during the evening peak period and end up creating a lot of chaos at the Ahinsan loop intersection. This creates a back up queue at the Gyinyase intersection thereby affecting the efficiency of the intersection.

4.3.3 Traffic Incidents

Traffic incidents such as vehicle break down and on-street parking are common features that cause delay to motorists.

On the Mampong route, heavy goods vehicles and broken down buses were seen parked along the road on the roadway due to lack of shoulders. Since the shoulders were broken or sometimes non existent the parking activities took some space of the roadway thereby reducing the effective lane width for moving vehicles. According to Hoel and Garber (1999) traffic flow is restricted by narrow lane width less than 3.63m. Drivers tend to shy away from road objects and compensate for these objects by reducing their speed. This is exactly what was experienced on the stretch of the Mampong road where articulated trucks and broken down buses had parked.

Such incidents were not seen on the Lake Road and the 24th February road on the days that the study was done though it is likely to occur.

4.3.4 Driver Behavior

This was one major contributory factor to congestion that was seen on all the three routes studied. Drivers, when looking for passengers tend to slow down causing delays to

vehicles behind them. "Trotros" and taxis were seen to pick up and drop off passengers at any location so long as there was the demand for their service. They stopped on the actual carriage way or at areas where they managed to stop on the shoulders, part of the body of the vehicles was in the roadway so other drivers had to slow down and pass such sections with caution thus reducing their speeds.

Where lay-byes were available, some "trotro" and taxi drivers had turned them to loading points preventing others from stopping to drop off or pick up passengers and this contributed to the reasons why others stopped on the carriageway to render such services to passengers.

On the 24th February road, notable areas of laybye abuse are KNUST junction, Anloga Junction and Oforikrom. The laybyes at KNUST and Anloga Junction are close to the signalized intersection. The activities of these drivers virtually blocks one lane at the approaches to the intersection and so when the green signal is on many vehicles are not able to cross the intersection as expected.

Laybye abuse at KNUST junction indicating one active lane with the other blocked by "trotros"

Loading and offloading activities right at the entrances to an intersection also caused delays and unsafe conditions to motorists. Some drivers were seen doing such activities at the Kaase junction and Gyinyase junction on the Lake road. Approaching the Kaase junction from Atonsu towards the CBD, commercial vehicles especially "trotros" do not use the bus stop provided. They rather prefer to render services to passengers on the road way and this causes delays and inconvenience to other motorists.

The Gyinyase junction is a well known inefficient intersection due to poor driver behavior. The "trotros" stop right at the intersection to serve passengers even though a laybye has been provided at about 50m before the intersection in front of the Catholic Church heading towards town. The "trotros" stop at this point very frequently and so for most time of the day the intersection is congested with passengers alighting and boarding the trotro.

4.3.5 Pedestrian Behavior and Road Side Activities

Road side activities were very significant along the Mampong road and the Lake road. These included sale of vehicles and vehicle spare parts, table top sales of food and general items and commercial stores.

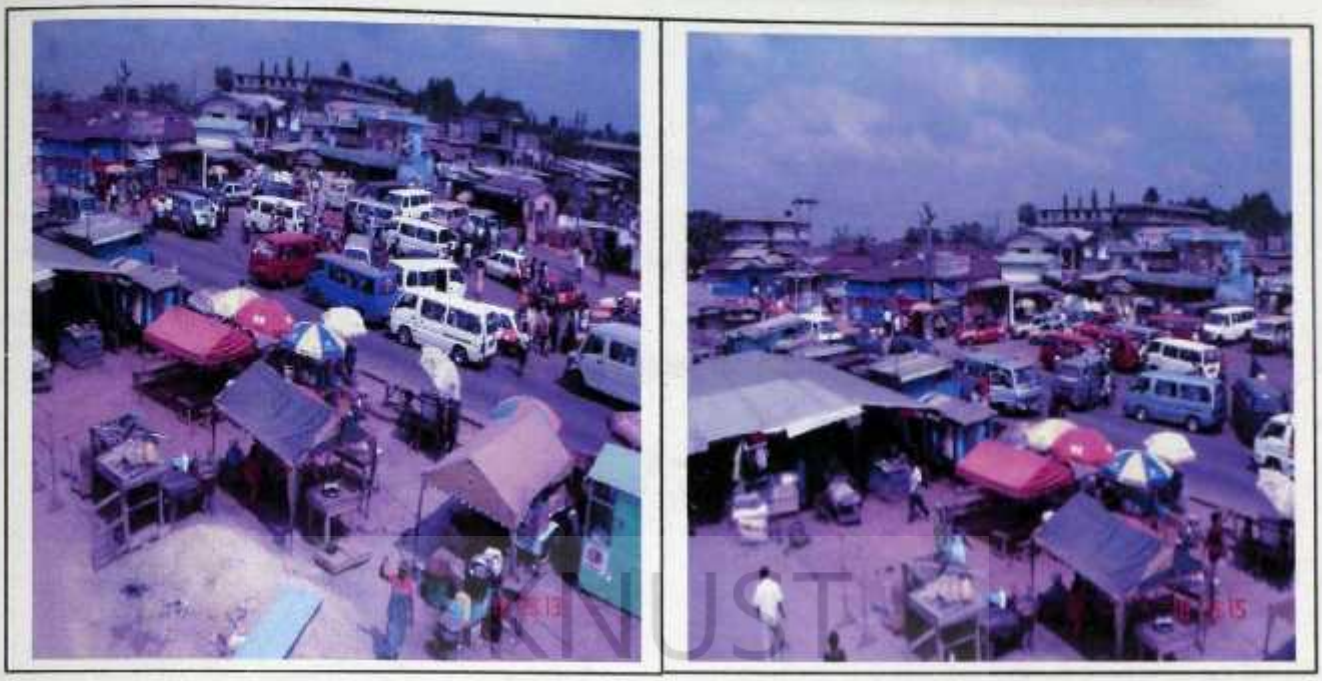
On the Mampong road in particular, a lot of mechanic workshops abut the road especially between Wesley College School and Suame New road junction. Within this same section, broken down buses and trucks were seen parked on the shoulders which were badly deteriorated. Pedestrians were also seen to cross the road at any point without regard to safety.

The 24th February road however did not have a lot of road side activities. However, hawkers were seen to be selling their goods at the signalized intersections at Amakom, Childrens Park, Anloga and KNUST. They walk in between vehicles during the red phase to sell their products. When a green comes on, they tend to slow down the movement of vehicles as they are seen trying to get off the road.

Typical hawking activities

Hawking activities were seen on the Lake road as well. The hawking activities were carried out during the congestion period when vehicle movement was slow or non existent due to gridlock situations. The section where this occurred is between Cocacola Bottling Plant Factory and the Ahinsan Loop intersection.

Terminal operations along the routes also caused a lot of delay to motorists as some of these vehicles were seen reversing into the roadway and making all sorts of maneuvers. Typical areas where this was observed are the Tafo terminal along the Mampong road and the Atonsu-Agogo terminal along the Lake road. The terminal activities also caused a lot of traffic build up and one could see that beyond these points, there was free flow of traffic.



Atonsu Agogo Terminal showing "trotros" loading on the carriageway and reversing onto the main road

4.3.6 Vehicle Composition and Conditions

It can not be overemphasized that the high volume of cars, taxis and "trotros" constitute to the congestion on the roads as seen from the tables in section 4.3. Some vehicles were also seen to be in poor condition with weak engines. Such vehicles even when there is free flow move slowly thereby impeding the movement of other vehicles that follow them.

Typical congestion scenes indicating high volume of "trotros" in the traffic stream

4.4 Bus Studies

4.4.1 Journey Speeds

The journey speeds between major sections along the three selected routes are presented below.

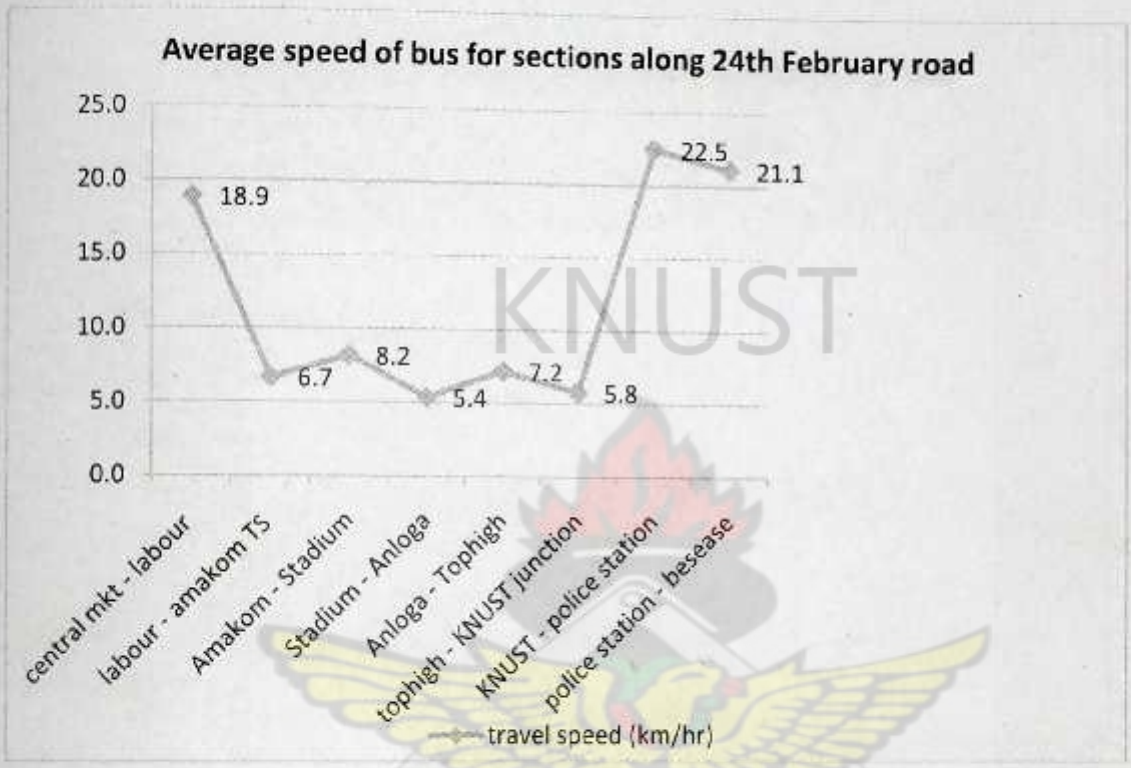


Figure 10: Average speed of bus between sections along 24th February Road – evening peak

The journey speed for dense areas in mixed traffic as reviewed should be between 10km/hr and 12km/hr. However, it can be seen from the figure above that this is not achieved for some sections of the 24th February road. Although from the central market, which happens to be the start point of the journey to labour roundabout lies within the CBD, a speed of 18.9km/hr was recorded. This could be attributed to the Asafo interchange which lies within this section and is able to manage the flows approaching and exiting it effectively and so there are hardly any delays.

A speed of less than 10km/hr is recorded between Labour roundabout and KNUST junction. This could be attributed to the congestion contributory factors such as the high volume of low occupancy vehicles (LOVs), driver behavior, intersection control devices

(ICDs) and traffic incidents discussed earlier in section 4.3. It is this section of the route that is of concern so as to minimize the delays experienced. Beyond KNUST junction there is free flow of vehicles except for the approaches to the roundabouts where the road reduces to a single lane.

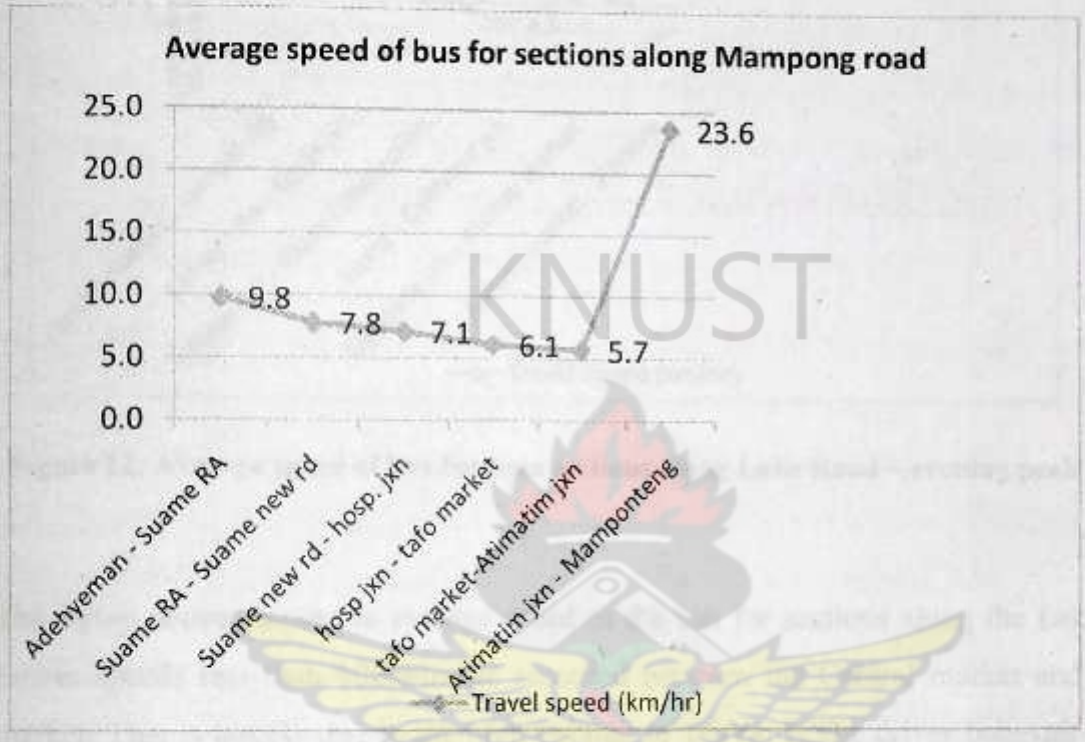


Figure 11: Average speed of bus between sections along Mampong Road – morning peak

The figure above shows the speeds recorded on the various sections on the Mampong road. Speeds less than 10km/hr were recorded right from the start point at Adehyeman to Atimatim junction. These low speeds are as a result of the causes of congestion which includes the high volume of LOVs, bad driver behavior, heavy pedestrian and road side activities especially at the Tafo terminal and poor intersection control devices as discussed above. Beyond Atimatim junction in the suburban areas up to the destination point speeds were up to 24km/hr.

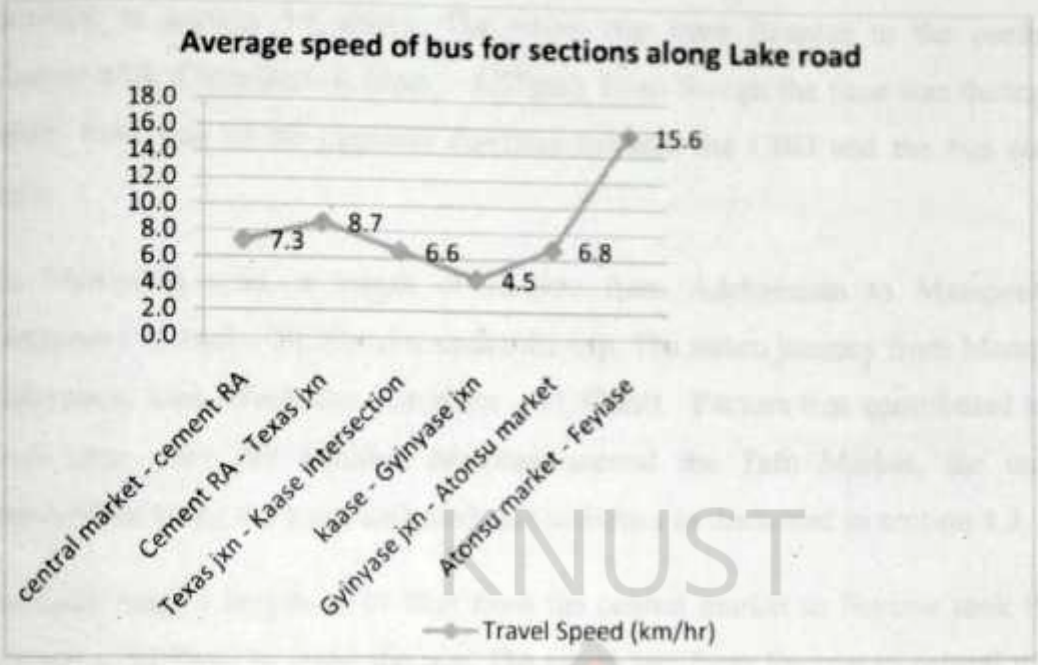


Figure 12: Average speed of bus between sections along Lake Road – evening peak

The figure above shows the average speed of the bus for sections along the Lake Road. Lower speeds less than 10km/hr are recorded between the Central market and Atonsu market. This is largely due to the high volume of LOVs, ICDs, driver behavior and the terminal at the Atonsu Market.

Reviewed average speeds were between 17km/hr and 22km/hr and comparing this to what was observed on all three routes indicates worsening situations.

4.4.2 Journey Time and Distance between stops

The journey time on the 24th February road, a length of 21.1km from the central market to Besease during the evening peak was 90minutes (4:35pm – 6:05pm). The evening peak period is when most people were returning home and this explains why it took the bus 90 minutes to cover a length of 21.1km. Other factors that contributed to the long travel time were the inappropriate timing of signals at Anloga and Amakom Traffic signals and the indiscipline behaviour of drivers at Anloga junction, Oforikrom and KNUST junction as

discussed in section 4.3 above. The return trip from Besease to the central market however took 47minutes (6:10pm – 6:57pm). Even though the time was during the peak period, flow was in the opposite direction towards the CBD and the bus could travel faster.

The Mampong road, a length of 13.3km from Adchyeman to Mamponteng took 47minutes (9:33am – 10:20am) to make the trip. The return journey from Mamponteng to Adehyeman took 67minutes (10:30am – 11:37am). Factors that contributed to the long travel time were the terminal activities around the Tafo Market, the uncontrolled intersections along the route and road side activities as discussed in section 4.3.

The Lake road, a length of 11.7km from the central market to Feyiase took 99 minutes (3:30pm – 5:09pm) to make the trip. The return trip from Feyiase to central market took 70 minutes (5:15pm – 6:25pm). Factors that contributed to the long travel time were the terminal activities at Atonsu Agogo, the indiscipline behaviour of drivers at Gyinyase and Kaase junction and the signal at Texas junction as discussed in section 4.3.

In all cases the large numbers of cars, taxis and "trotros" in the vehicle fleet also contributed to the long travel times as presented earlier in section 4.2.

For all the three routes the total hours travelled each day to and from work is between 2-3 hours and this exceeds the recommended average of 1.0 - 1.5 hours.

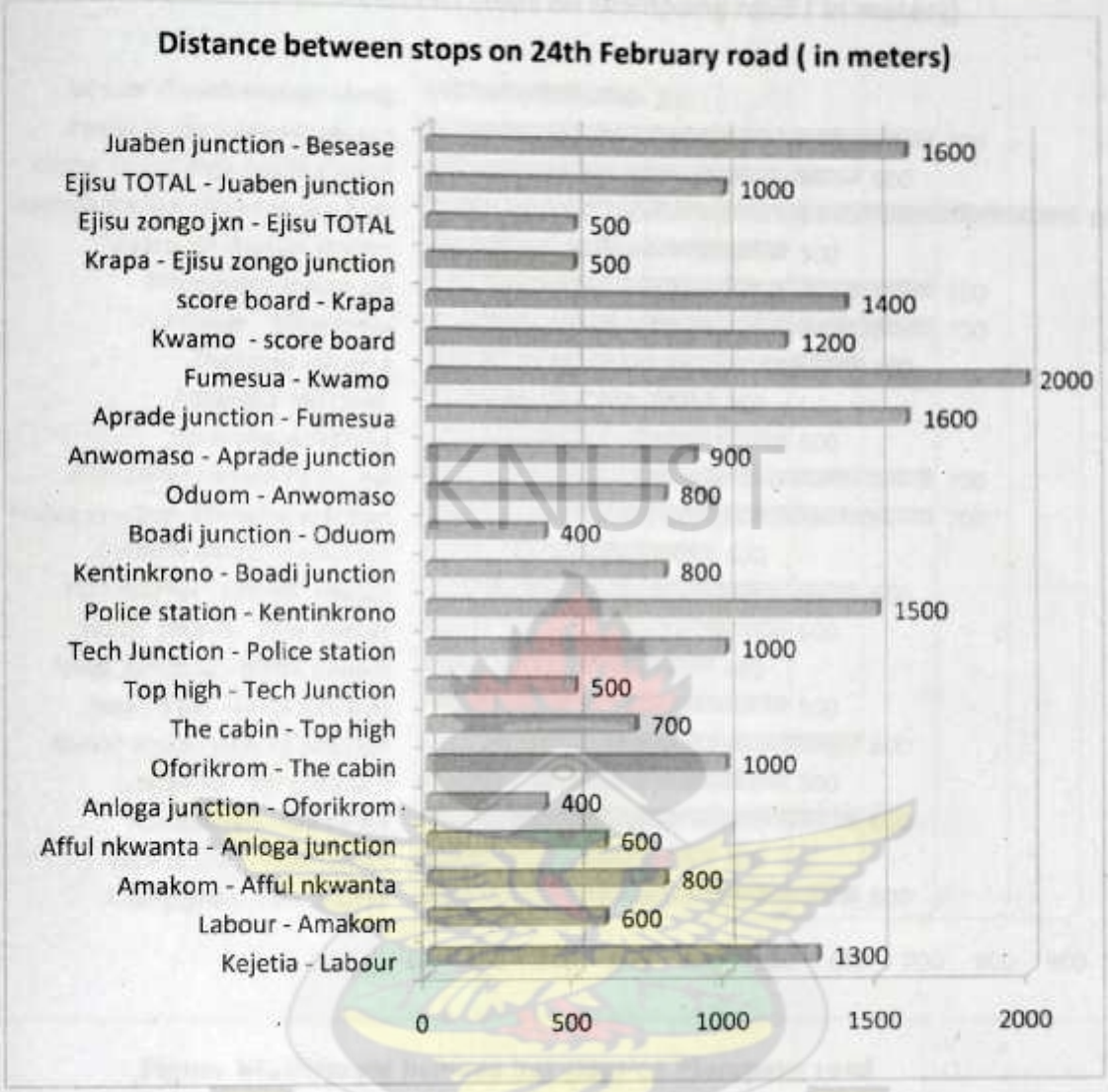


Figure 13: Distance between stops along 24th February road

Figure 13 shows the distance between adjacent bus stops on the 24th February road ranging from a minimum of 400m to a maximum of 2000m. The calculated average stop distance was 960m. With the standard bus stop distance for dense urban areas between 300-500m and for low density urban areas between 500-1000m, the distance between the bus stops can be said to be generally satisfactory. The buses however do not have designated bus stops. The stops are influenced by the passengers. For example there is a stop between the cabin and Top High bus stops, but the bus did not stop there during this particular trip because passengers were neither there to board the bus nor alight at the said stop.

Figure 14: Distance between bus stops on Mampong road

Figure 14 above shows the distance between adjacent bus stops on the Mampong road, ranging from a minimum of 300m to a maximum of 900m. The calculated average stop distance was 560m. With the standard bus stop distance for dense urban areas between 300-500m and for low density urban areas between 500-1000m, the distance between the bus stops on the Mampong road is adequate.

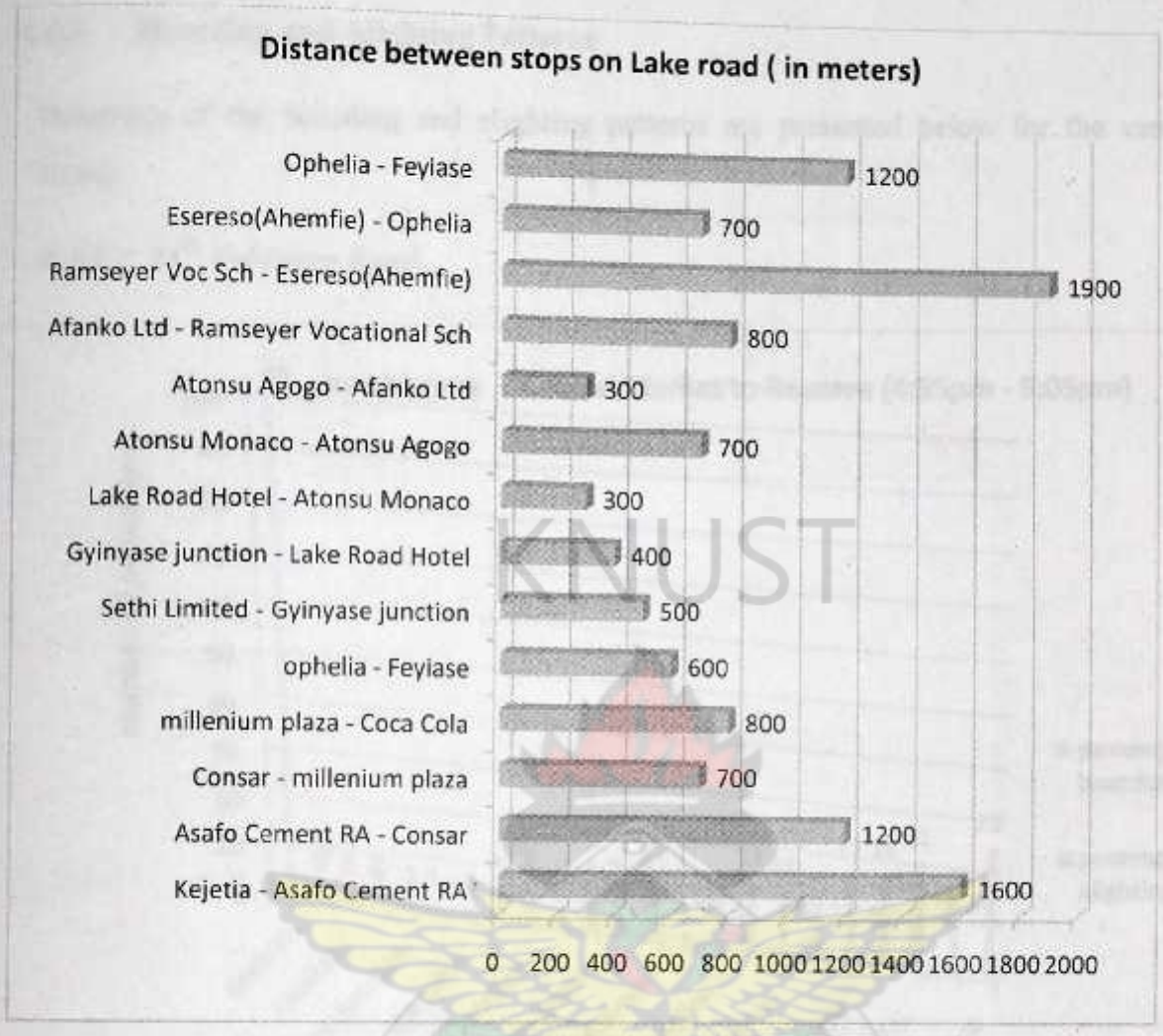


Figure 15: Distance between bus stops on Lake Road

Figure 15 above shows the distance between adjacent bus stops on the Lake road, ranging from a minimum of 300m to a maximum of 1900m. The calculated average stop distance was 830m with the standard bus stop distance for dense urban areas between 300-500m and for low density urban areas between 500-1000m, the distance between the bus stops can be said to be generally satisfactory.

4.4.3 Boarding and Alighting Patterns

Summary of the boarding and alighting patterns are presented below for the various routes.

4.4.3.1 24th February Road

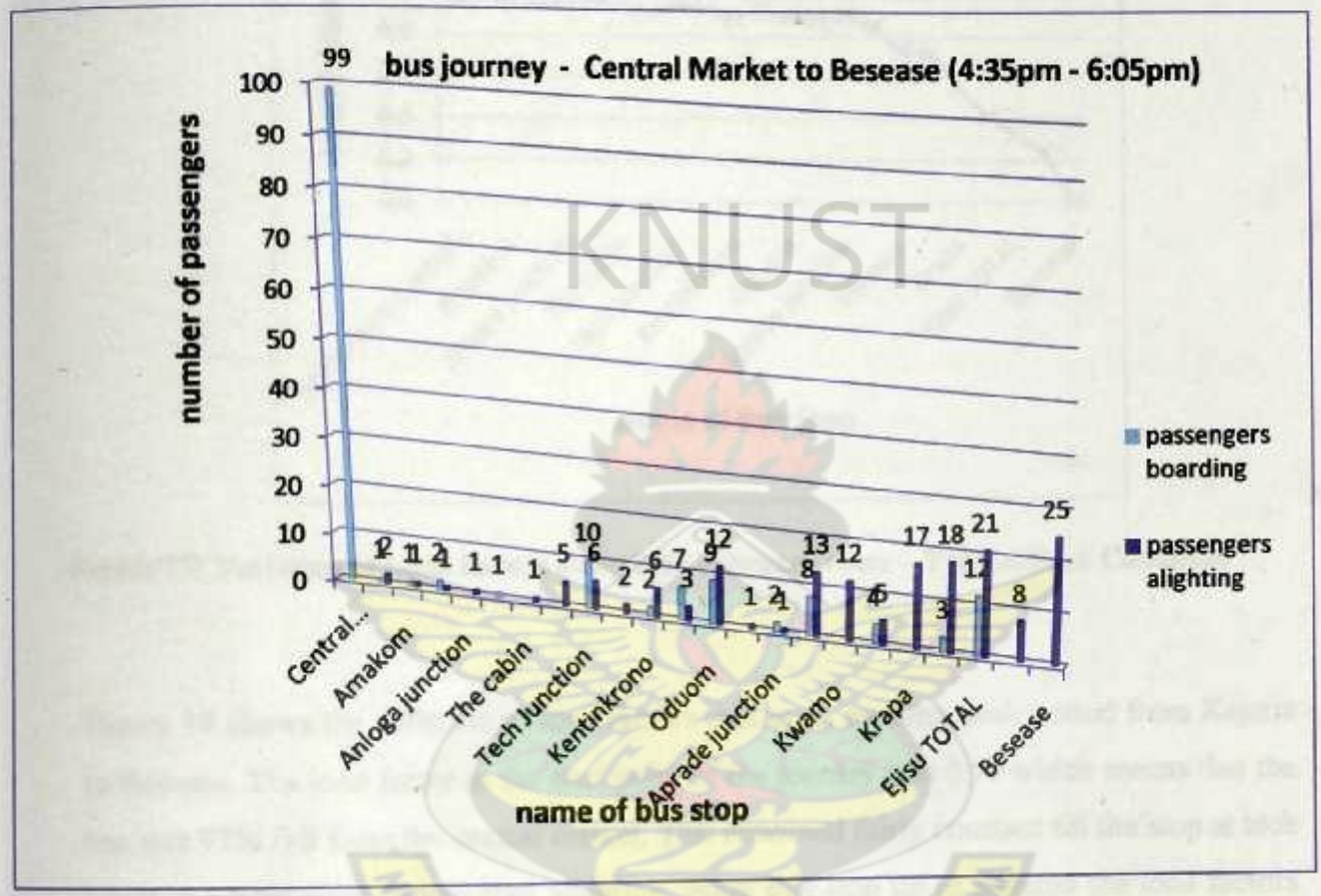


Figure 16: Boarding and alighting pattern along 24th February route - Central Market to Besease

Figure 16 shows that majority of the passengers boarded the bus at the central market, the start point of the trip. The subsequent stops up to The Cabin had one or two people alighting and boarding. Most passengers started alighting from tech junction onwards. This explained the evening peak trend of people moving from work to their homes since most people boarded from the CBD and started alighting at stops within residential areas.

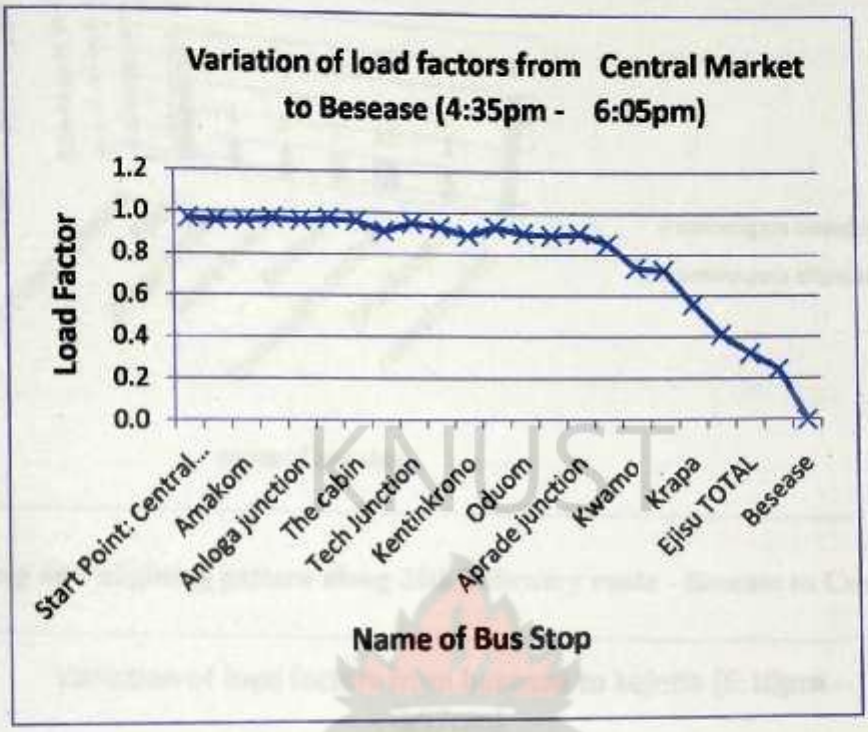


Figure 17: Variation of Load factors along 24th February route – Typical Peak Condition

Figure 17 shows the variation of load factors during an evening peak period from Kejetia to Besease. The load factor at the start point of the journey was 0.97 which means that the bus was 97% full from the central market. This remained fairly constant till the stop at tech junction where most people start alighting. From this stop up to Kwamo the load factors remain fairly constant again till it starts droping up to zero at the last stop. The computed average load factor for the entire trip is 0.81 and this indicates that the MMT bus is well patronized on this route.

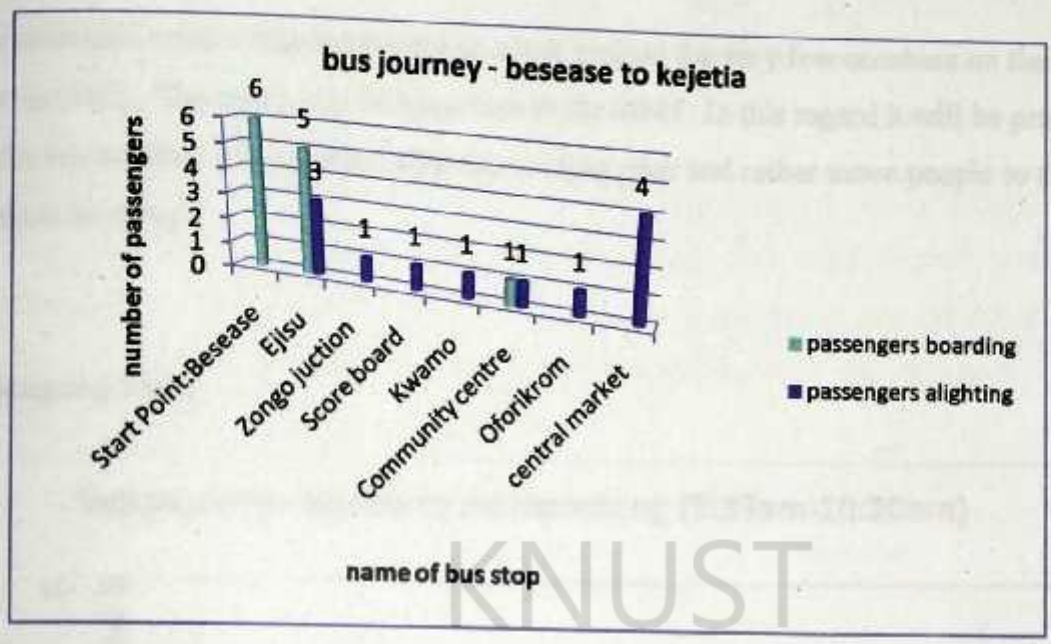


Figure 18: Boarding and alighting pattern along 24th February route - Besease to Central Market

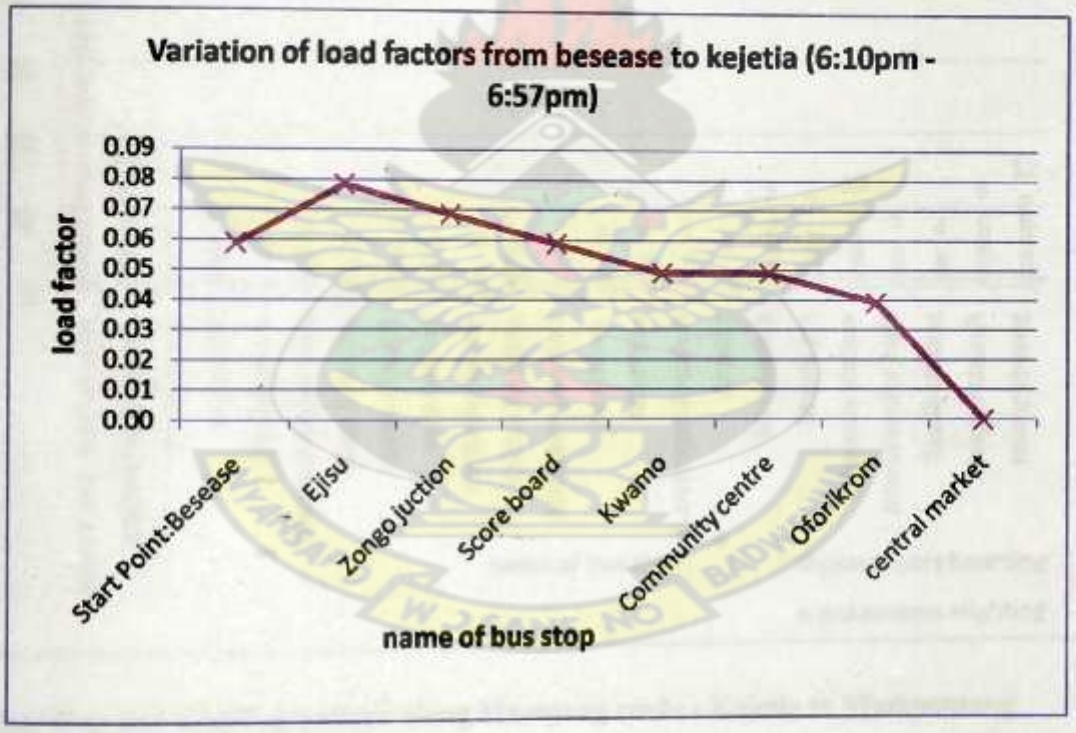


Figure 19: Variation of Load factors along 24th February route - Typical Off Peak Condition

Figures 18 and 19 show the loading and alighting pattern and load factors for the return journey from Besease to Central market on the 24th February route. It is observed that very few people were on board the bus for the entire trip. The load factor varied from 0.04 to 0.08 with a computed average of 0.06. The time of travel from 6:10pm - 6:57pm, by which

time activities in the CBD have come to a halt explain the very few numbers on the bus for the return trip. The return trip is thus a loss to the MMT. In this regard it will be prudent for the bus to sleep over at Ejisu after the evening peak and rather move people to the CBD the next morning.

4.4.3.2 Mampong Road

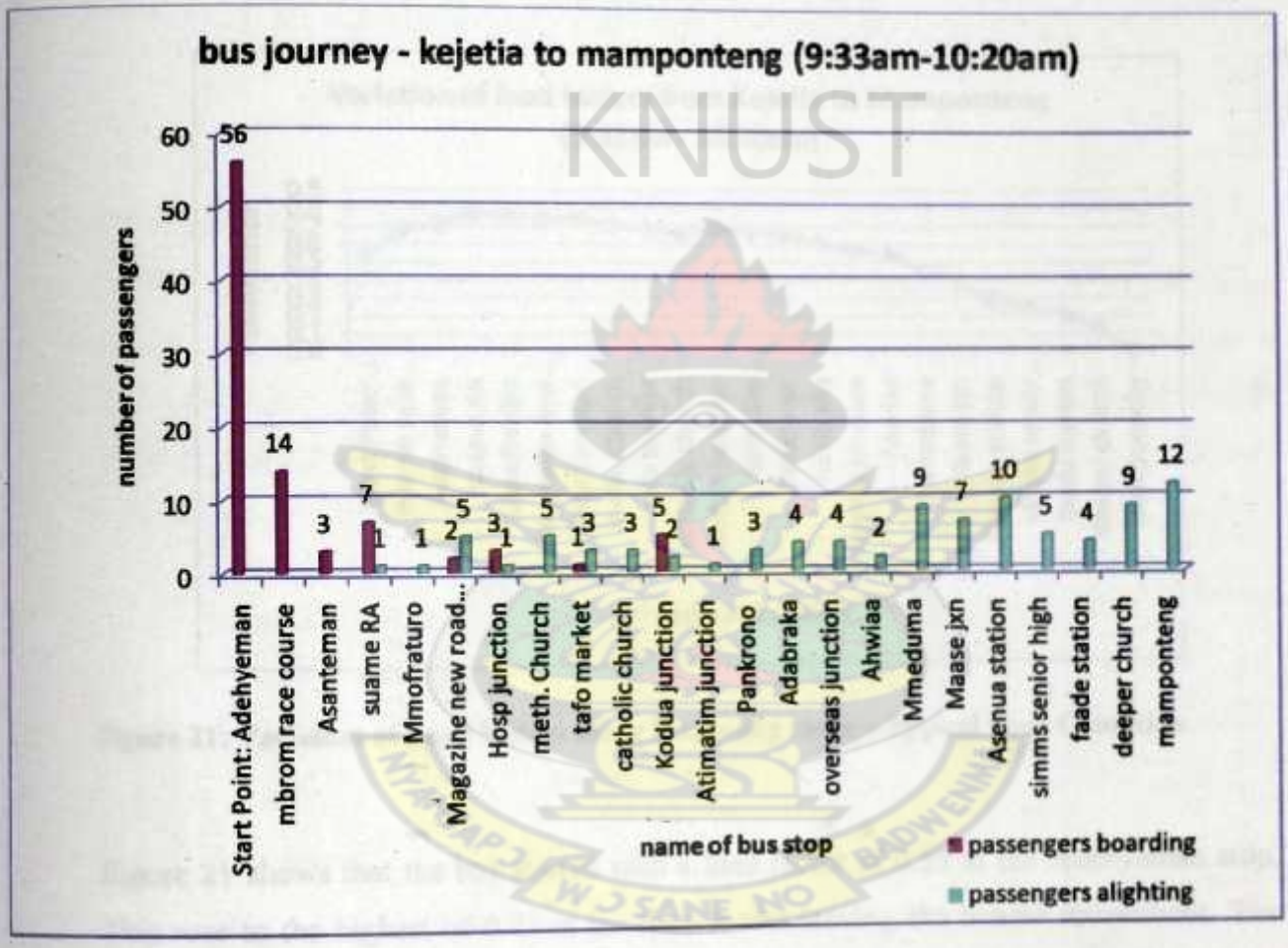


Figure 20: Boarding and alighting pattern along Mampong route - Kejetia to Mamponteng

The figure above shows the boarding and alighting pattern on the Mampong road from 9:33am to 10:20 am. It can be seen that most people boarded the bus at Adehyeman and Race course stops. It was observed that most of these passengers were market women who

had come to buy foodstuffs from the race course, a popular early morning market in Kumasi where farmers bring their produce to sell in bulk to the market women.

Even though it is expected that few people will be moving away from the CBD during the morning peak, the contrary was rather experienced since the market women come to buy the foodstuffs and send to the satellite markets along the Mampong route to sell. It can also be seen that significant number of people started alighting from Tafo onwards where the satellite markets and residential areas are located.

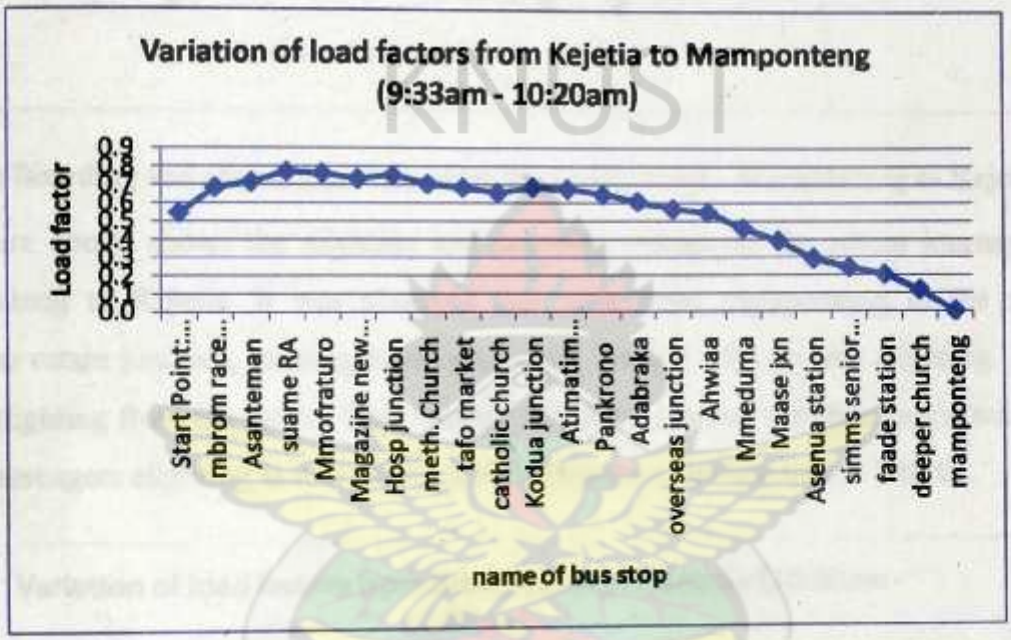


Figure 21: Variation of Load factors along Mampong route – Typical Peak Condition

Figure 21 shows that the bus started with a load factor of 0.55 at the Adehyeman stop. This rose to the highest of 0.77 at the time it was leaving the Suame roundabout. The computed average load factor was 0.59. This means that the bus was 59% full throughout the journey.

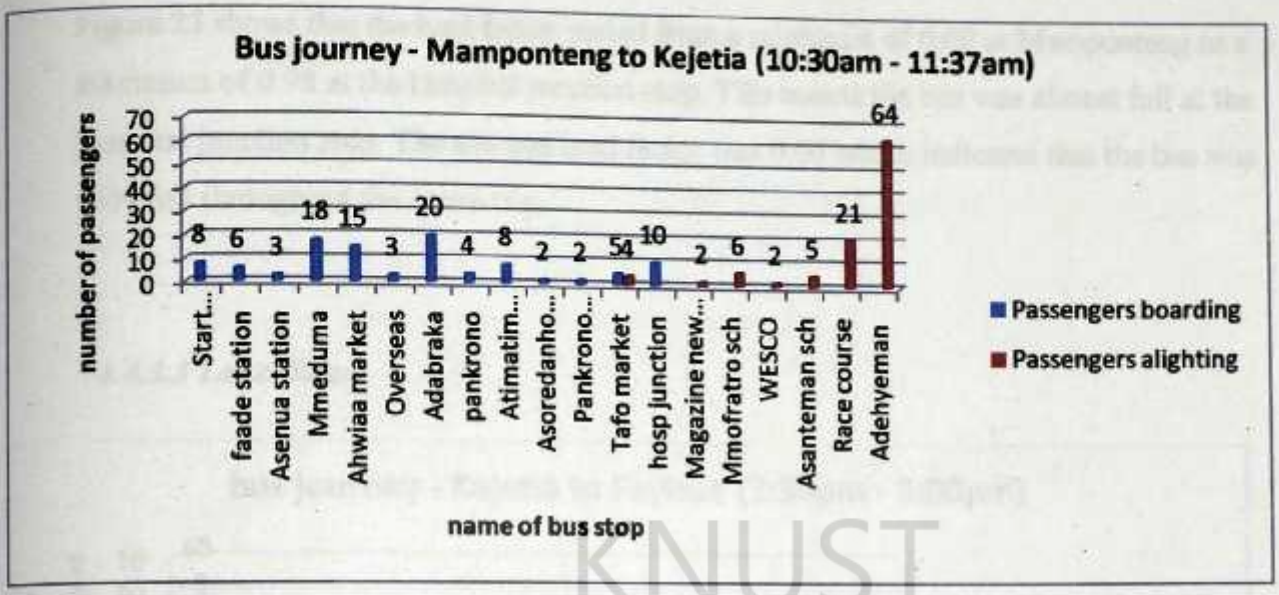


Figure 22: Boarding and alighting pattern along Mampong route - Mamponteng to Kejetia

The figure above shows the alighting and boarding pattern on the return journey from Mamponteng to Kejetia. It was observed that right from mamponteng to the stop at Pankrono estate junction, passengers only boarded the bus with no one alighting. People started alighting from the stop at Tafo market where commercial activities begin with most of the passengers alighting at race course and Adehyeman, the last stop at Kejetia.

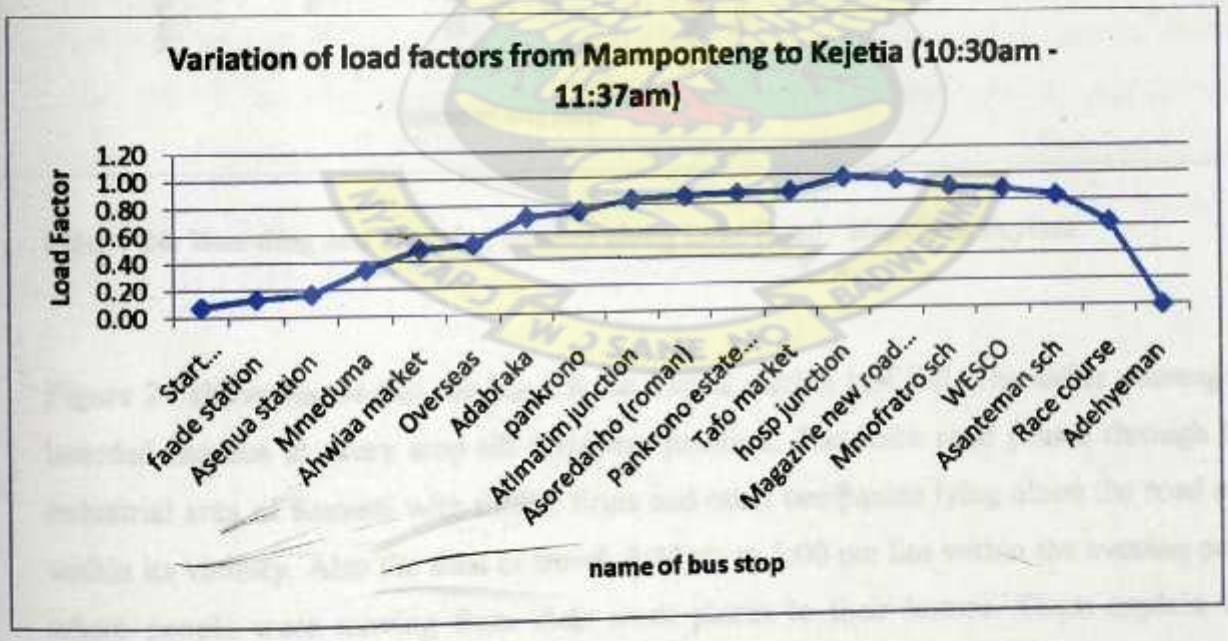


Figure 23: Variation of Load factors along Mampong route - Typical Peak Condition

Figure 23 shows that the load factor varied from a minimum of 0.08 at Mamponteng to a maximum of 0.98 at the Hospital junction stop. This means the bus was almost full at the Hospital junction stop. The average load factor was 0.66 which indicates that the bus was 66% full throughout the entire trip.

4.4.3.3 Lake Road

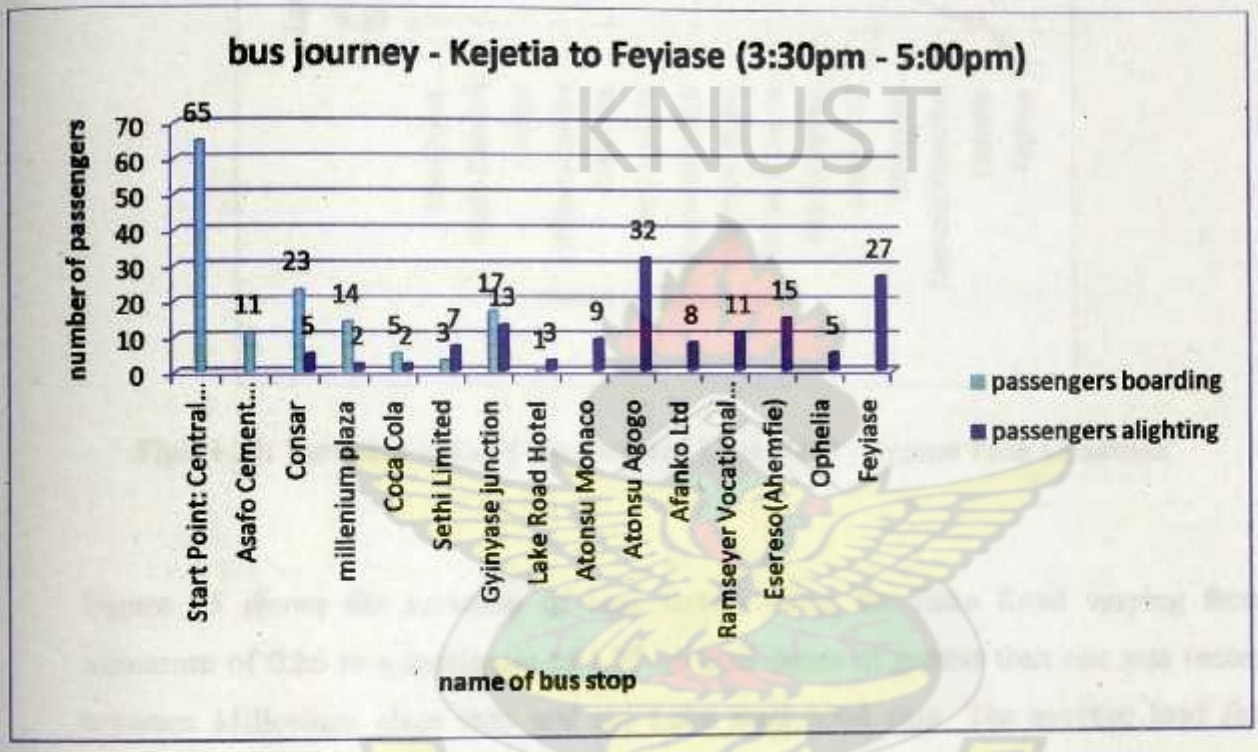


Figure 24: Boarding and alighting pattern along Lake Road - Kejetia to Feyiase

Figure 24 above shows that the bus left the central market half full. Thereafter passengers boarded the bus at every stop till Gyinyase junction. The Lake road passes through the industrial area of Kumasi with timber firms and other companies lying along the road and within its vicinity. Also the time of travel, 3:30pm to 5:00 pm lies within the evening peak where people were moving from their work places to their homes. These explain the number of passengers boarding the bus at Consar, millennium plaza and Gyinyase junction stops respectively. The Consar bus stop in particular, has a primary school, a timber firm, a

construction company, the Ministry of Agriculture, Kumasi office surrounding it and that explains why as much as 23 passengers boarded the bus at that stop.

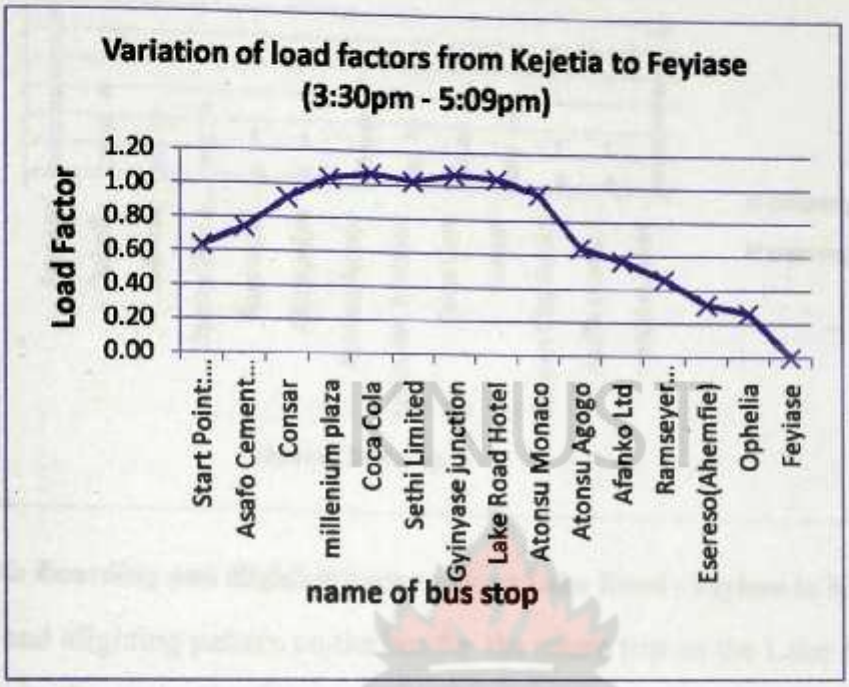


Figure 25: Variation of Load factors along Lake Road - Typical Peak Condition

Figure 25 shows the variation of load factors along the Lake Road varying from a minimum of 0.26 to a maximum of 1.07. A load factor of greater than one was recorded between Millenium plaza stop and the Lake road hotel stop. The average load factor throughout the journey was 0.72 implying the bus was 72% full throughout the entire journey. This shows that the bus is highly patronized on this route.

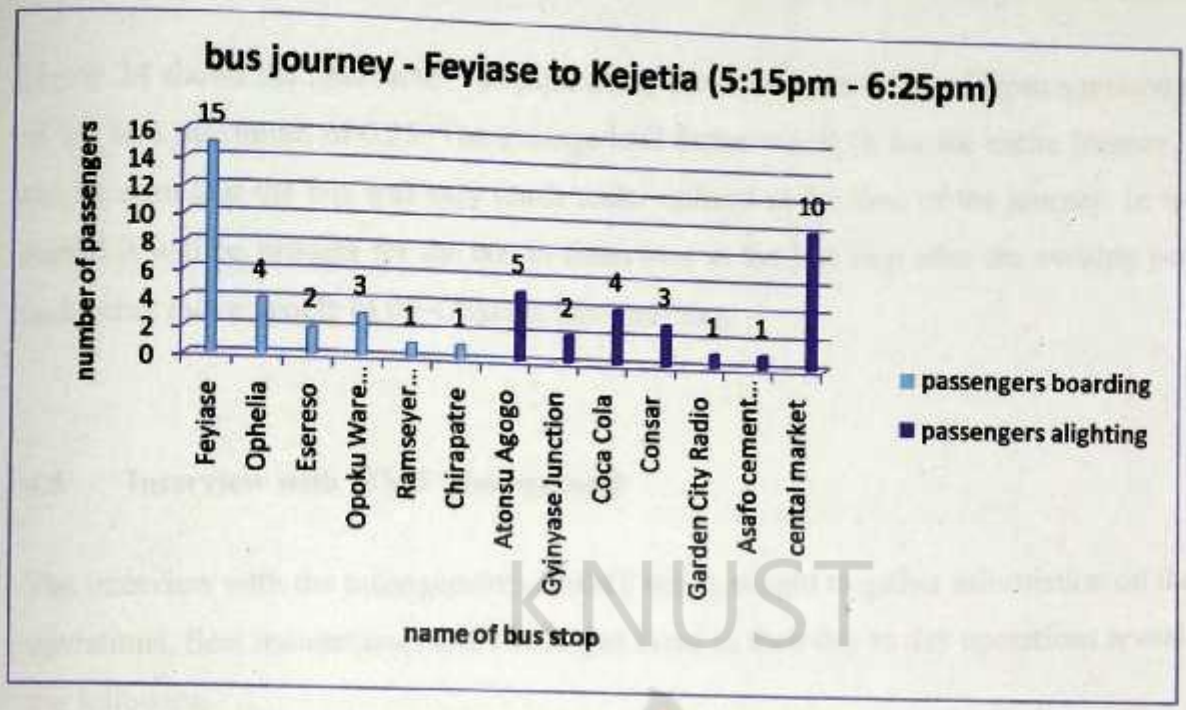


Figure 26: Boarding and alighting pattern along Lake Road - Feyiase to Kejetia

Boarding and alighting pattern on the bus for the return trip on the Lake road from Feyiase to Kejetia is shown in the figure above. Passengers only boarded between Feyiase and Chriapatre and alighted from Atonsu Agogo stop till it got to the central market.

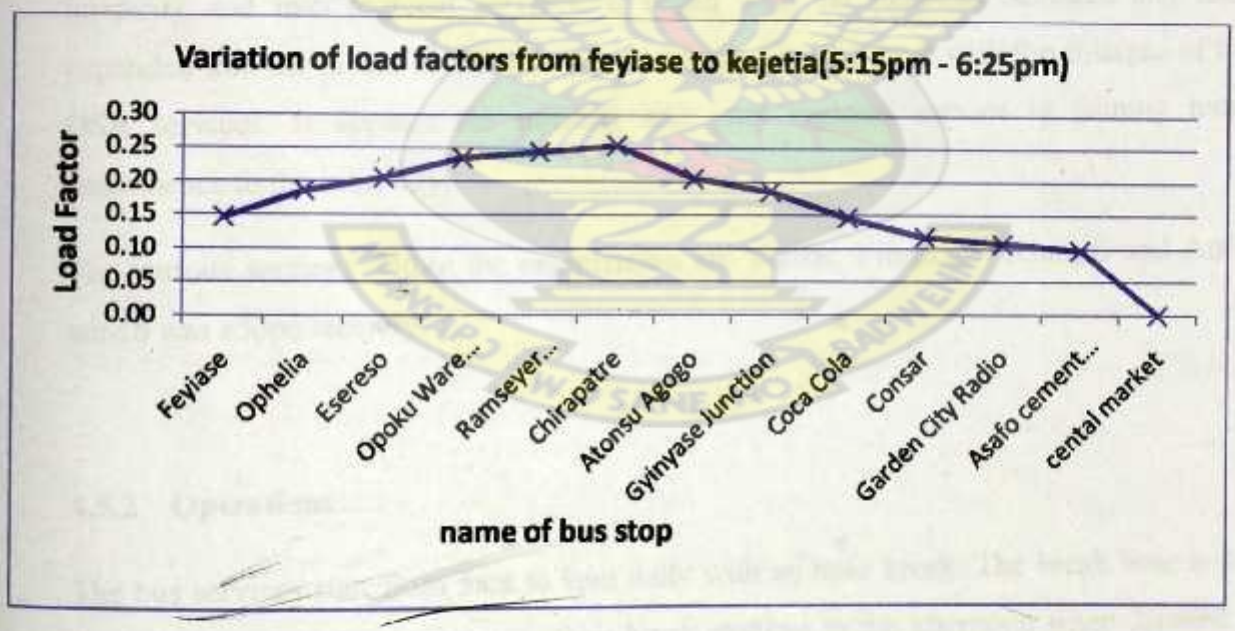


Figure 27: Variation of Load factors along Lake Road - Typical off Peak Condition

Figure 24 shows the load factor variation along the Lake road. It varied from a minimum of 0.1 to a maximum of 0.25. The average load factor was 0.16 for the entire journey. It can be seen that the bus was very much under-utilized at the time of the journey. In this regard it will be prudent for the bus to sleep over at the last stop after the evening peak and rather move people to the CBD the next morning.

4.5 Interview with MMT Management

The interview with the management of MMT which sought to gather information on their operations, fleet maintenance and challenges faced in their day to day operations revealed the following.

4.5.1 Establishment and Organization

The MMT office in Kumasi started operations from March 2003. It renders intra-city, inter-city and inter-regional services. It began with the intra-city services and later expanded into the others because there was a large demand for it with the collapse of the OSA services. It appears the intercity and inter regional service is gaining more prominence to the intra-city.

The various sections within the organization are Traffic, Finance, Technical and Audit which was added recently.

4.5.2 Operations

The bus services start from 5am to 9pm daily with an hour break. The break time is not fixed. Drivers and conductors take their break anytime in the afternoon when demand is low. All intra-city services begin from the central point in the city. The buses used for this service are the Yaxing single and double decker and the VDL Neoplan. All buses

have seating capacity of 33 and full capacity with standees of 120 except the single decker Yaxing which has full capacity of 102.

All routes have one bus except the Lake road which has two for the intra-city service. There are plans to expand the service to other routes. The new routes are informed by requests received from residents and/or a follow up by the MMT to determine its feasibility through studies and surveys.

4.5.3 Fleet Maintenance

Maintenance of the buses is done locally at the Company's workshop or at Neoplan Ghana Limited in Kumasi. The MMT has its own mechanics that are trained every quarter by expatriates from Belgium and Holland from where some of the buses are manufactured.

The usual periodic maintenance activities are carried out as scheduled and all other works such as replacement of parts are done as and when necessary. New parts are procured and kept in store to be used when necessary.

4.5.4 Fares and Fare Collection

The Kumasi office of the MMT does not fix the fares for the various routes. All fares are fixed at the head office in Accra. The operations manager can however put in a request for the review of fares when certain parameters such as fuel prices change.

Generally MMT fares are 15% lower than other operators but the intra-city service fare is 10% lower than other operators. Fares are fixed for a route and do not depend on the distance travelled along that particular route.

4.5.5 Support

MMT is owned jointly by the Government of Ghana (45%) and Private Owners (55%) comprising State Insurance Company (SIC), National Investment Bank (NIB), Ghana Oil Company Limited (GOIL), Agriculture Development Bank (ADB), Prudential Bank and Social Security and National Insurance Trust (SSNIT).

The office is yet to receive any form of financial support from the Government and Private Owners. Technical support and advice are however received from the Board on how to improve the operations.

4.5.6 Challenges

The MMT services are faced with challenges that hinder the smooth running of their operations. Notable among them which the Management Team expressed concern of are;

- Terminals – The Kejetia terminal, the largest and well constructed terminal in the city used to be the terminal from which the MMT buses operate from. Due to some financial challenges between the Management of the terminal and the MMT, they are unable to load from the terminal presently. MMT thus loads from unauthorized locations and this activity poses so much inconvenience and unsafe conditions to the passengers.
- Labour Agitations – The MMT management is often confronted with agitations from the workers over better conditions of service especially on salary increases. This compels them to embark on strikes when the Government is not able to meet their demands. This disrupts the bus services and passengers get stranded in their transactions.
- Bus lanes – The Management of MMT are of the opinion that the provision of bus lanes will go a long way to promote their operations by increasing their journey speed and reducing travel time.

4.6 Summary of Measures to improve the Operations of MMT

4.6.1 Increasing flow and Travel Speed

As noted with the results and observations made during the bus journeys in section 4.4, the high densities experienced are as a result of the low speeds along the sections of the road. It is recalled under section 4.3 that driver and pedestrian behavior, abuse of laybyes, presence of terminals along the routes and level of road side activities contributed to the low speeds experienced on the routes. The study revealed that some bus stops especially at Oforikrom and KNUST were being used as stations along the routes where taxis and "trotros" especially park and wait for passengers. By so doing their activities spill over onto the carriageway thereby reducing the lane width. It is proposed that drivers should be educated on the use of laybyes, shoulders and the roadway in general so as to avoid their unauthorized activities along the route. Road side activities should be kept away from the edge of the shoulder. The carriageway should be well defined for motorists to see clearly ahead of them so as not to impede the flow on the routes.

It was also observed that terminal activities along the Mampong and Lake roads contributed to the low flows and speeds. These activities included loading and off loading of passengers and goods by the road side, turning maneuvers such as reversing and U-turns. It is proposed that the terminals be relocated away from the main roads.

It was observed that the laybye at KNUST is not appropriate. The KNUST community has a primary and secondary schools, tertiary institution and a hospital located within it. These facilities serve the communities around and within it. As a result, the demand for public transport especially during the evening peak is very high as most passengers are seen waiting and scrambling for vehicles. The laybye which is a drop off and pick up site is therefore inappropriate for the kind of service required. It is proposed that a terminal be constructed within the vicinity to serve the people.

The loading and offloading activities right at the Gyinyase intersection should be discouraged. Drivers and passengers should be made to use the designated bus stops located just about 50m from the intersection. The Police MTTU should ensure that laybyes are used for the purpose for which they are built.

The Mampong road had heavy goods vehicles and broken down buses parked on the shoulders along the route. There are also numerous mechanic workshops along the route. Vehicles spare parts are also sold along the route. On street parking along arterials should be discouraged.

As part of strategies by the Department of Urban Roads to relieve Kumasi of congestion, some arterial roads have been selected for dualisation with interchanges to be constructed at major intersections. The Lake Road and Mampong road are included in the improvement. However the first phase of the dualisation of the lake road ends at the Kaase Intersection. This means that two lanes from the CBD would be narrowing into a single lane towards Atonsu and vice versa. It will be recalled that the Kaase Intersection to the Atonsu Market/terminal is one critical section along the route where speeds are very low. The speeds recorded within this section were Kaase intersection to Gyinyase junction 4.5km/hr and Gyinyase intersection to Atonsu Market/terminal, 6.8km/hr. Also the BCEOM/ACON report (2004) indicated that the arterials in Kumasi have exceeded their capacity and proposed that they be dualised. Therefore it would be more appropriate to extend the dualisation up to the Atonsu Market/terminal to ease the congestion on the road.

4.6.2 Use of High Occupancy Vehicles during peak periods

The data collected on vehicle mix indicates that there is a high percentage of Low Occupancy Vehicles in the vehicle fleet on all the roads. These are taxis, "trotros" and cars. Taxis and "trotros" constitute 60% of the vehicles, cars and pick ups are about 30%, medium and large buses are about 7% and the rest are trucks. Of the 7% medium/large buses, the MMT buses are virtually non existent in the traffic stream with a very insignificant volume of 0.06% in the 12 hour count. As discussed in section 4.2 the vehicles start peaking from 7:00am to 10:00am and from 3:00pm to 6:00pm. Similarly more passengers are transported to and from work, school, market etc. within this same period. The issue is how to carry more passengers during these times faster to their various destinations. One major factor contributing to the congestion of the roads is the high

volume of Low Occupancy Vehicles (LOVs) in the traffic mix. Reviews on travel difficulties in Kumasi as discussed in section 2.8 identified the presence of LOVs as the main cause of congestion. Emphasis was laid on the use of HOVs for public transport.

As indicated in the tables below, a reduction in the number of taxis and "trotros" with an equivalent replacement with HOVs in this case, the MMT bus can cause significant change in the volume of vehicles on the routes.

Table 8: Systematic reduction in volume of "trotros" and taxis and increase in MMT buses for 24th February road.

Vehicle type	taxi (veh/hr)	Trotro (veh/hr)	medium/large bus (veh/hr)	MMT (veh/hr)	cars/PU/ Trucks	total	% reduction in volume
Actual flows	1007	651	116	1	926	2701	**0**
10% reduction in taxis and "trotros"	907	586	116	14	926	2549	**5.7**
20% reduction in taxis and "trotros"	806	521	116	27	926	2396	**11.3**
30% reduction in taxis and "trotros"	705	456	116	40	926	2243	**17.0**
40% reduction in taxis and "trotros"	604	391	116	53	926	2090	**22.6**
50% reduction in taxis and "trotros"	504	325	116	66	926	1937	**28.3**
60% reduction in taxis and "trotros"	403	260	116	79	926	1784	**34.0**
70% reduction in taxis and "trotros"	302	195	116	92	926	1632	**39.6**
80% reduction in taxis and "trotros"	201	130	116	105	926	1479	**45.3**
90% reduction in taxis and "trotros"	101	65	116	118	926	1326	**50.9**
100% reduction in taxis and "trotros"	0	0	116	131	926	1173	**56.6**

As mentioned earlier a 5% reduction in traffic volume can cause a 10-30% increase in average vehicle speeds. (Nair and Kumar, 2008). Also, according to Khisty and Kent Lall (2006) any reduction in traffic volume greater than 10% can cause an improvement in the

LOS of a road. In view of these it is expected that the reduction in trotro and taxi volumes to be replaced by MMTs can cause significant improvement in speeds and LOS which will subsequently reduce the congestion level on the road.

On the 24th February road, a 10% reduction each in "trotros" and taxis translates to 13 MMT buses using a capacity of 100 passengers per MMT bus.

Table 9: Systematic reduction in volume of "trotros" and Taxis and increase in MMT buses for Mampong road.

Vehicle type	taxi (veh/hr)	Trotro (veh/hr)	medium/large bus (veh/hr)	MMT (veh/ hr)	cars/PU/ Trucks	total	% reduction in volume
Actual flows	443	609	154	1	546	1753	**0**
10% reduction in taxis and "trotros"	399	548	154	10	546	1657	**3.4**
20% reduction in taxis and "trotros"	354	487	154	19	546	1561	**9.0**
30% reduction in taxis and "trotros"	310	426	154	28	546	1464	**14.6**
40% reduction in taxis and "trotros"	266	365	154	37	546	1368	**20.2**
50% reduction in taxis and "trotros"	222	304	154	46	546	1272	**25.8**
60% reduction in taxis and "trotros"	177	244	154	55	546	1176	**31.4**
70% reduction in taxis and "trotros"	133	183	154	64	546	1080	**37.0**
80% reduction in taxis and "trotros"	89	122	154	73	546	983	**42.7**
90% reduction in taxis and "trotros"	44	61	154	82	546	887	**48.3**
100% reduction in taxis and "trotros"	0	0	154	91	546	791	**53.9**

On the Mampong road, a 10% reduction each in "trotros" and taxis translates into 9 MMT buses using a capacity of 100 passengers per MMT bus.

Table 10: Systematic reduction in volume of "trotros" and Taxis and increase in MMT buses for Lake road.

Vehicle type	taxi (veh/hr)	Trotro (veh/hr)	medium/large bus (veh/hr)	MMT (veh/hr)	cars/PU/Trucks	total	% reduction in volume
Actual flows	647	430	92	1	658	1828	0
10% reduction in taxis and "trotros"	582	387	92	9	658	1728	5.5
20% reduction in taxis and "trotros"	518	344	92	17	658	1629	10.9
30% reduction in taxis and "trotros"	453	301	92	25	658	1529	16.4
40% reduction in taxis and "trotros"	388	258	92	33	658	1429	21.8
50% reduction in taxis and "trotros"	324	215	92	41	658	1330	27.3
60% reduction in taxis and "trotros"	259	172	92	49	658	1230	32.7
70% reduction in taxis and "trotros"	194	129	92	57	658	1130	38.2
80% reduction in taxis and "trotros"	129	86	92	65	658	1030	43.6
90% reduction in taxis and "trotros"	65	43	92	73	658	931	49.1
100% reduction in taxis and "trotros"	0	0	92	81	658	831	54.5

On the Lake road, a 10% reduction each in "trotros" and taxis translates into 8 MMT buses using a capacity of 100 passengers per MMT bus.

It is in respect of this that the use of HOV's is being proposed to be used for public transport. However the trend of the volumes and passengers on the routes indicate that it will be more economical to use the HOV'S during the morning and evening peak periods since this is the period during which most people are moved.

Operators of the taxis and "trotros" should be involved in the planning and implementation stages so as not to oppose the idea of using HOV's for public transport during peak periods. The transportation system should be planned such that taxis and "trotros" would operate a complementary service where they would bring passengers from the neighboring communities to the bus stops along the arterial roads to board the MMT buses. The private operators could also be made to own shares in the MMT. In this case, they would have a greater sense of commitment and support it to operate efficiently. The private operators can also be encouraged to shift from the use of taxis and "trotros" by giving them tax reliefs for the importation of HOVs.

4.6.3 Intersection Control Measures

Priority controlled intersections were identified to be bottleneck areas during the study. It is proposed that the intersections at New road junction and Tafo hospital junction on the Mampong road, Susuanso junction on the 24th February road and the Kaase junction on the Lake road be signalized. The Ahensan loop intersection and Gyinyase junction on the Lake road should also be signalized and coordinated. The old controller at the Texas junction should be replaced with a new one. All signals should be maintained regularly and Authorities should ensure that they are in good working condition at all times.

Buses should be given priority at the signalized intersections by giving them a queue jump so as they do not queue up with other vehicles.

4.6.4 Complementary Measures

The buses should be scheduled to move at regular times. At the bus stops their schedule should be displayed for passengers to know the expected arrival times of the bus. This would make the service reliable and attract more patronage.

Road signs; bus stop signs, no stopping and no parking signs should be installed along the road at designated places to inform drivers and passengers. Lighting and shelter should

also be provided at the bus stops. This gives a sense of security to passengers and they would be obliged to wait at the bus stops to board the buses.

The MMT buses do not have well constructed terminals. Passengers are exposed to the harsh weather conditions as they wait for buses. The financial strife between the Management of Kejetia terminal and MMT should be resolved so that the buses can use the terminal. Along the routes terminals should be developed at the destination sites so that buses would park there at the end of a days work and bring passengers to the CBD the next morning.

Another way of reducing the congestion on the roads is to encourage Car pools and Van pools in organizations to carry workers to and from work.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

1. Cars constitute 451 (21%) of total vehicles per hour, Taxis constitute 699 (33%) of total vehicles per hour, Pick Ups/Jeeps constitute 155 (7%) of total vehicles per hour, "trotros" constitute 563 (27%) of total vehicles per hour, Buses constitute 121 (6%) of total vehicles per hour and trucks constitute 104 (5%) of total vehicles per hour.
2. Cars carry 947 (7%) of persons per hour, Taxis carry 2447 (17%) of persons per hour, Pick Ups/Jeeps carry 573 (4%) of persons per hour, "trotros" c arry 6927 (49%) of persons per hour and Buses carry 2877 (21%) of persons per hour and trucks carry 333 (2%) of persons per hour.
3. Congestion on the roads is due mainly to the road condition, intersection control devices, driver behavior and pedestrian and road side activities along the road and high volume of low occupancy vehicles.
4. The Tafo terminal along the Mampong road and the Atonsu-Agogo terminal along the Lake road caused a lot of inconveniences and delay to motorists.
5. Abuse of laybys by using them for stations also caused a lot of inconveniences and delays to motorists. Typical areas include the KNUST junction, Oforikrom and Anloga junction on the 24th February road,
6. Average journey speeds recorded are 14km/hr, 12.1km/hr and 9km/hr for 24th February road, Mampong road and Lake Road respectively. Reviewed average speeds were between 17km/hr and 22km/hr indicating a reduction of speeds by an average of 8km/hr.
7. Lowest speeds recorded within dense areas are between 4.5km/hr – 9km/hr which is less than the recommended speed of buses in dense areas in mixed traffic of 10-12km/hr.
8. In the sub-urban areas, speeds recorded were up to 24km/hr.
9. Round trip journey time of 2hours 17 minutes is recorded for 24th February road and this occurs in the evening peak period. For the Mampong road round trip journey time is 1hour 54 minutes and this occurs in the morning peak and for the Lake road the evening

peak period recorded a time of 2hours 49mins. These times all exceed the recommended daily travel time of 1-1.5 hours for buses. The round trip times also exceed the reviewed values of 1-1.5 hours which indicates worsening situations.

10. Total number of stops on the 24th February road, a length of 21.1km was 22 with an average stop distance of 960m. Number of stops on Mampong road (12.4km) was also 22 with an average stop distance of 560m. The Lake Road (11.7km) had 14 stops with an average stop distance of 830m.
11. MMT bus fares for the intra-city bus services are 10% lower than that of other operators and this served as an incentive for people to board the MMT buses despite the other challenges.

5.2 Recommendations

To Government and Kumasi Metropolitan Assembly (KMA)

1. Government should encourage the use of High Occupancy Vehicles for public transport on the arterials.
2. Car pools and Van pools should be encouraged in organizations.
3. Tafo and Atonsu Agogo lorry stations should be relocated away from the main roads.
4. The Police MTTU should educate drivers on the use of laybyes, shoulders and the roadway in general and ensure compliance.
5. Terminal sites should be identified and developed by the KMA for the MMT buses.
6. A terminal should be developed for the KNUST community away from the main road.
7. There is bound to be agitations from taxi and "trotro" operators on the use of HOVs for public transport on the arterials. For a successful transition, there is the need to explore how to integrate these operators into the use of the HOVs.

To Department of Urban Roads

1. Dualisation of the Lake road should be extended from the Kaase intersection to the Atonsu Market/terminal.
2. New Road Junction and Tafo Hospital Junction on the Mampong road, Susuanso Junction on the 24th February road and the Kaase Junction on the Lake road should be signalized. The Ahensan loop intersection and Gyinyase junction on the Lake road should also be signalized and coordinated.
3. All signals should be maintained regularly and Authorities should ensure that they are in good working condition at all times.
4. Buses should be given priority at the signalized intersections by giving them a queue jump.

5. Road signs (bus stop signs, no stopping and no parking signs) should be placed at designated places to inform and educate drivers and passengers.
6. Lighting and shelter should also be provided at the bus stops.

To MMT Management

1. For high patronage the MMT buses should operate during the morning and evening peak periods.
2. The buses should be scheduled to move at regular times with schedules displayed at bus stops.

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APPENDICES

Appendix One –Classified Master Counts Data

Date	**22-Apr-09**
Road name	**24th Feb road**
Location	**family chapel**
Period	**6am - 6pm**
EB	**East bound to KNUST**
WB	**West bound to Adum**

East bound to KNUST							
time	car	taxi	PU/Vans/jeeps	small bus ("trotros")	medium/large bus	trucks	total
6am -7am	122	196	29	129	10	20	**505**
7am -8am	236	375	71	250	40	29	**1001**
8am -9am	358	589	115	378	64	61	**1565**
9am -10am	326	555	103	342	56	53	**1436**
10am - 11am	286	452	89	300	47	43	**1216**
11am - 12noon	289	457	90	304	48	44	**1231**
12noon- 1pm	320	507	101	336	55	52	**1372**
1pm-2pm	307	485	96	322	52	48	**1311**
2pm-3pm	317	506	97	333	54	51	**1358**
3pm-4pm	318	514	99	334	55	51	**1371**
4pm-5pm	374	607	122	393	67	67	**1630**
5pm-6pm	402	661	131	421	74	74	**1763**
total	**3654**	**5903**	**1143**	**3843**	**622**	**594**	15759

west bound to Adum							
time	car	taxi	PU/Vans/jeeps	small bus ("trotros")	medium/large bus	trucks	total
6am -7am	173	270	46	177	31	18	**714**
7am -8am	274	432	83	283	55	45	**1172**
8am -9am	358	597	113	372	74	68	**1582**
9am -10am	381	613	123	399	80	75	**1671**
10am -11am	353	579	111	366	72	67	**1549**
11am - 12noon	344	560	108	356	70	64	**1503**
12noon-1pm	323	508	100	334	65	58	**1389**
1pm-2pm	316	498	98	327	64	57	**1359**
2pm-3pm	307	483	94	317	62	54	**1317**
3pm-4pm	303	476	95	313	61	53	**1300**
4pm-5pm	298	479	91	307	60	52	**1286**
5pm-6pm	403	691	129	418	82	80	**1803**
total	**3833**	**6186**	**1191**	**3968**	**776**	**691**	**16645**

Summary of Classified Count for 24th February Road - (Veh/day)

vehicle type	East bound	West bound	total 2 way volume	% of total
car	3654	3833	7487	23.1
taxi	5903	6186	12089	37.3
PU/Vans/jeeps	1143	1191	2334	7.2
small bus ("trotros")	3843	3968	7811	24.1
medium/large bus	622	776	1398	4.3
trucks	594	691	1285	4.0
total	15759	16645	32404	100.0
Directional split (%)	48.6	51.4		

Date	**22-Apr-09**
Road name	**Mampong road**
Location	**wesley college**
Period	**6am - 6pm**
SB	**South bound to Kejetia**
NB	**North bound to Mampong**

South bound to Kejetia							
time	car	taxi	PU/Vans/jeeps	small bus ("trotros")	medium/large bus	trucks	total
6am -7am	106	133	44	251	66	42	642
7am -8am	154	210	61	298	76	48	847
8am -9am	169	223	68	310	78	51	899
9am -10am	161	213	60	304	77	50	864
10am - 11am	168	224	61	312	79	52	896
11am - 12noon	159	211	62	302	75	49	859
12noon- 1pm	161	213	62	304	77	50	867
1pm-2pm	175	236	68	318	80	54	930
2pm-3pm	199	274	75	342	86	60	1037
3pm-4pm	196	269	75	340	85	59	1025
4pm-5pm	162	215	64	304	77	50	872
5pm-6pm	216	302	82	362	90	65	1116
total	2025	2723	782	3748	945	631	10854

North bound to Mampong							
time	car	taxi	PU/Vans/jeeps	small bus ("trotros")	medium/large bus	trucks	total
6am -7am	61	70	23	199	54	24	431
7am -8am	143	196	53	285	72	46	794
8am -9am	169	241	65	312	79	53	919
9am -10am	162	230	63	305	77	50	888
10am -11am	189	273	70	333	83	57	1005
11am -12noon	168	222	61	308	75	51	885
12noon-1pm	128	176	48	269	70	41	731
1pm-2pm	190	278	70	336	84	58	1017
2pm-3pm	177	257	66	323	81	55	959
3pm-4pm	198	288	73	343	83	61	1046
4pm-5pm	138	192	51	279	72	45	776
5pm-6pm	125	171	46	266	69	41	718
total	1847	2594	689	3559	900	582	10171

Summary of classified count for Mampong road - (Veh/day)

vehicle type	South bound	North bound	total 2 way volume	% of total
car	2025	1847	3872	18.4
taxi	2723	2594	5317	25.3
PU/Vans/jeeps	782	689	1471	7.0
small bus ("trotros")	3748	3559	7307	34.7
medium/large bus	945	900	1845	8.8
trucks	631	582	1213	5.8
total	10854	10171	21025	100.0
Directional split (%)	51.6	48.4		

Date

22-Apr-09

Road name Lake road

Location Coca Cola Factory

Period 6am - 6pm

EB East bound to Atonsu

WB West bound to Kejetia

East bound to Atonsu							
time	car	taxi	PU/Vans/jeeps	small bus ("trotros")	medium/large bus	trucks	total
6am -7am	87	138	32	91	20	24	392
7am -8am	197	313	71	205	45	48	879
8am -9am	194	308	70	203	44	53	872
9am -10am	181	287	66	189	41	49	812
10am -11am	171	272	62	179	39	47	771
11am -12noon	168	267	61	176	38	46	756
12noon-1pm	218	346	79	227	49	41	961
1pm-2pm	189	301	69	198	43	52	852
2pm-3pm	201	319	73	210	46	55	903
3pm-4pm	206	328	75	216	47	56	929
4pm-5pm	233	371	85	244	53	53	1038
5pm-6pm	252	401	92	263	57	61	1126
total	2296	3653	835	2400	522	584	10290

West bound to Kejetia							
time	car	taxi	PU/Vans/jeeps	small bus ("trotros")	medium/large bus	trucks	total
6am -7am	139	221	51	151	32	38	631
7am -8am	250	398	91	273	57	53	1121
8am -9am	276	440	100	297	63	59	1235
9am -10am	266	423	97	278	60	61	1185
10am -11am	206	327	75	245	47	56	956
11am -12noon	195	310	71	204	44	53	878
12noon-1pm	218	348	79	228	50	60	983
1pm-2pm	216	344	79	226	49	59	973
2pm-3pm	183	290	66	191	41	50	821
3pm-4pm	207	329	75	216	47	56	931
4pm-5pm	211	335	77	220	48	57	948
5pm-6pm	218	346	79	227	49	59	979
total	2584	4111	940	2757	587	662	11642

Summary of classified count for Lake road - (Veh/day)

vehicle type	East bound	West bound	total 2 way volume	% of total
car	2296	2584	4880	22.3
taxi	3653	4111	7764	35.4
PU/Vans/jeeps	835	940	1775	8.1
small bus ("trotros")	2400	2757	5157	23.5
medium/large bus	522	587	1109	5.1
trucks	584	662	1246	5.7
total	10290	11642	21931	100.0
directional split (%)	46.9	53.1		

Appendix Two – Details of Bus Journey Studies

Route: 24th February road

trip direction	Kejetia to Besease		Start Time	4:35 PM
route length	21.1km		Finish Time	6:05pm
Date	22nd April 2009		total trip time	1hr 30mins
Bus Stop	Cumulative Distance(m)	Stop Time(mins)	No. of People Boarding	No. of People Alighting
Start Point: Central Market, Kejetia	0		99	
Labour (Goil)	1300	0.13	1	2
Amakom	1900	0.06	1	1
Afful nkwanta	2700	0.13	2	1
Anloga junction	3300	0.08		1
Oforikrom	3700	0.07	1	
The cabin	4700	0.18		1
Top high	5400	0.43		5
Tech Junction	5900	1.33	10	6
police station	6900	0.16		2
Kentinkrono	8400	0.24	2	6
Boadi junction	9200	1.04	7	3
Oduom	9600	1.45	9	12

anwomaso	10400	0.11		1
Aprade junction	11300	0.20	2	1
Fumesua	12900	1.43	8	13
Kwamo	14900	1.23		12
score board	16100	1.08	4	5
Krapa	17500	1.21		17
Ejisu zongo junction	18000	0.57	3	18
Ejisu TOTAL	18500	1.13	12	21
Achiakrom junction	19500	0.30		8
Besease	21100			25

trip direction	Besease to Kejetia		Start Time	6:10 PM
route length	21.1km		Finish Time	6:57pm
date	22nd April 2009		total trip time	47mins
Bus Stop	Cumulative Distance(m)	Stop Time(mins)	No. of People Boarding	No. of People Alighting
Start Point:Besease	0		6	
Ejisu	2600	1.04	5	3
Zongo juction	3100	0.23		1
Score board	5000	0.08		1
Kwamo	6200	0.07		1
Police station	14200	0.07	1	1
Oforikrom	17400	0.13		1
central market	21100			4

Route: Mampong road

trip direction	Adehyeman to Mamponteng		Start Time	9:33 AM
route length	12.4km		Finish Time	10:20am
date	23rd April 2009		total trip time	47mins
Bus Stop	Cumulative Distance(m)	Stop Time(mins)	No. of People Boarding	No. of People Alighting
Start Point: Adehyeman	0		56	
mbrom race course	600	4.54	14	
Asanteman	1000	0.34	3	
Wesco (suame RA)	1600	0.31	7	1
Mmofraturo	2100	0.04		1
Magazine new road junction	2700	0.12	2	5
Tafo hosp intersection	3200	0.34	3	1
Methodist church	3600	0.09		1
Tafo market	4100	0.54	1	3
Catholic church	4700			
Kondua junction	5100	0.10		3
Atimatim junction	5800	0.16	5	2

Pankrono	6500	0.08		1
Adabraka	7000			
Overseas	7400	0.11		3
Ahwiaa	8000	0.15		4
Mmeduma	8700	0.13		4
Maase junction	9400	0.44		9
Asenua station	9900	0.54		7
simms senior high	10800	0.40		10
faade station	11400	0.18		5
Deeper Church	12100	0.09		4
mamponteng	12400	0.15		9

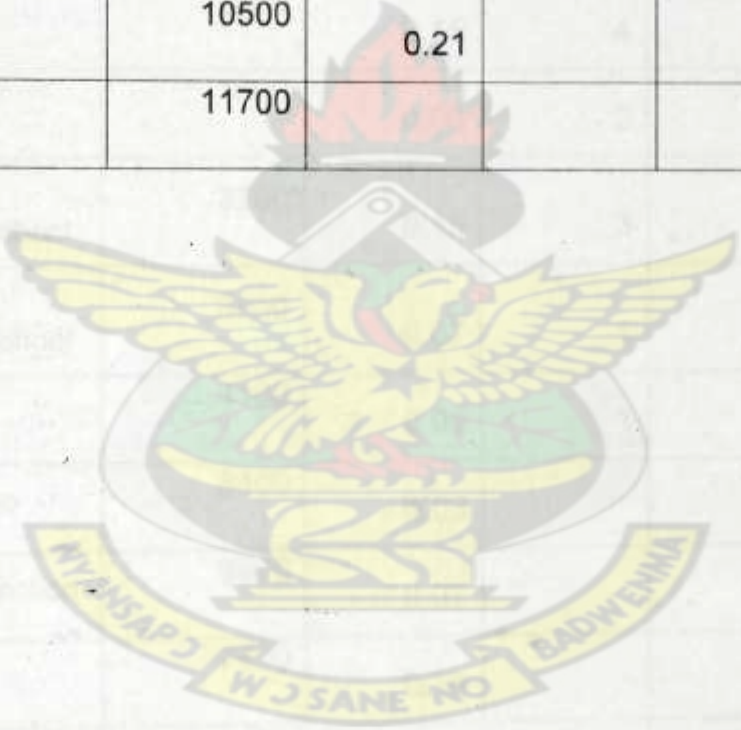
trip direction	**Mamponteng to Adehyeman**		**Start Time**	**10:30am**
route length	**12.4km**		**Finish Time**	**11:37am**
date	**23rd April 2009**		**total trip time**	**1 hr 7mins**
Bus Stop	**Cumulative Distance(m)**	**Stop Time(mins)**	**No. of People Boarding**	**No. of People Alighting**
Start Point:mamponteng	0		8	
faade station	1000	0.15	6	
Asenua station	2500	0.10	3	
Mmeduma	3700	1.29	18	
Ahwiaa market	4400	0.23	15	
Overseas	5000	0.13	3	
Adabraka	5400	1.03	20	
Pankrono	5900	1.33	4	
Atimatim junction	6600	0.53	8	
Asoredanho (roman)	7700	0.08	2	
Pankrono estate junction	8000	0.07	2	
Tafo market	8300	0.16	5	4
Hosp. Junction	9200	0.15	10	
Magazine new road int	9700	0.08		2

Mmofratro sch	10300	0.07		6
WESCO	10500	0.05		2
Asanteman sch	11400	0.24		5
Race course	11800	1.00		21
Adehyeman	12400			64

Route: Lake road

trip direction	**Kejetia to Feyiase**		**Start Time**	**3:30pm**
route length	**11.7km**		**Finish Time**	**5:09pm**
date	**7th May 2009**		**total trip time**	**1 hr 39mins**
Bus Stop	**Cumulative Distance(m)**	**Stop Time(mins)**	**No. of People Boarding**	**No. of People Alighting**
Start Point: Central Market, Kejetia	0		65	
Asafo Cement Roundabout	1600	1.13	11	
Consar	2800	2.08	23	5
millenium plaza	3500	0.43	14	2
Coca Cola	4300	0.18	5	2
Sethi Limited	4900	0.21	3	7

Gyinyase junction	5400	1.03	17	13
Lake Road Hotel	5800	0.13	1	3
Atonsu Monaco	6100	0.16		9
Atonsu Agogo	6800	1.53		32
Afanko Ltd	7100	0.58		8
Ramseyer Vocational Sch	7900	0.22		11
Esereso(Ahemfie)	9800	0.28		15
Ophelia	10500	0.21		5
Feyiase	11700			27



trip direction	Feyiase to central market		Start Time	5:15pm
route length	11.7km		Finish Time	6:25pm
date	7th May 2009		total trip time	1 hr 10mins
Bus Stop	Cumulative Distance(km)	Stop Time(mins)	No. of People Boarding	No. of People Alighting
Feyiase	0		15	
Ophelia	1200	0.15	4	
Esereso	1800	0.08	2	
Opoku Ware Vocational School	3300	0.15	3	
Ramseyer Vocational School	3800	0.07	1	
Chirapatre	4100	0.05	1	
Atonsu Agogo	5400	0.03		5
Gyinyase Junction	6400	0.07		2
Coca Cola	7400	0.14		4
Consar	9000	0.10		3
Garden City Radio	9600	0.06		1
Asafo cement Roundabout	10100	0.04		1
cental market	11700			10

Appendix Three – Journey Speeds and Times per Major Sections along Routes

24th February road

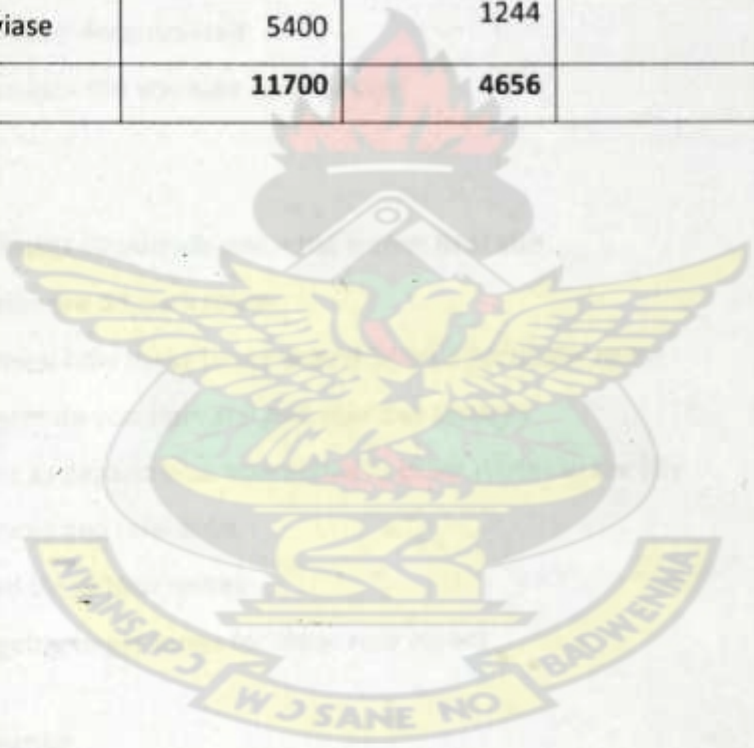
major section	Distance(m)	Travel time(sec)	Travel speed(km/hr)	no of stops
Central market - Labour	2200	418	18.9	1
Labour - Amakom TS	700	378	6.7	1
Amakom - Stadium	400	175	8.2	1
Stadium - Anloga	950	636	5.4	1
Anloga - Tophigh	2100	1050	7.2	3
Tophigh - KNUST junction	550	343	5.8	1
KNUST –Police station	1000	160	22.5	1
Police station - Besease	13200	2250	21.1	13
Total	**21100**	**5410**	**14.0**	**22**

Mampong road

major section	Distance(m)	Travel time(sec)	Travel speed(km/hr)	no of stops
Adehyeman - Suame RA	1600	585	9.8	3
Suame RA - Suame new rd	1100	510	7.8	2
Suame new rd - Hosp. jxn	500	255	7.1	1
Hosp junction - Tafo market	900	535	6.1	2
Tafo market-Atimatim junction	1700	1075	5.7	3
Atimatim jxn - Mamponteng	6600	1005	23.6	11
Total	**12400**	**3965**	**11.3**	**22**

Lake road

major section	Distance(m)	Travel time(sec)	Travel speed(km/hr)	no of stops
central market - cement RA	1600	787	7.3	1
Cement RA - Texas junction	1700	702	8.7	2
Texas junction - Kaase intersection	800	437	6.6	2
Kaase - Gyinyase junction	1200	958	4.5	2
Gyinyase junction - Atonsu market	1000	528	6.8	2
Atonsu market - Feyiase	5400	1244	15.6	5
Total	**11700**	**4656**	**9.0**	**14**



Appendix Four – Structured Questionnaire used in interview with the Management of MMT

MSC. ROAD AND TRANSPORTATION ENGINEERING

THESIS TOPIC: TRAFFIC MANAGEMENT OPTIONS TO IMPROVE THE OPERATIONS OF THE METRO MASS TRANSIT BUS SERVICES IN KUMASI

MMT MANAGEMENT QUESTIONNAIRE

Establishment and Organisation

1 When did MMT start operations in kumasi
2 How many routes do you operate on presently
3 What is the organisational structure of the company
4 Is the kumasi office decentralised
5 If no what decisions can you take on your own

Operations

6 What type of buses do you use and what is your fleet size
7 How many buses are on each route
8 How do you know how many buses should be on a particular route
9 When and where do you start and end your bus services
10 Are there plans to expand your operations to other routes in the city
11 If yes what routes and how soon
12 What informed these new routes
13 How are you going to get buses for these new routes

Fleet Maintenance

14 Where do you maintain your buses
15 How often do you get new buses
16 How often do you maintain your buses
17 What kind of maintenance do you do on the buses
18 Where do you get your spare parts from, new or used
19 Where are your mechanics trained

20 Are they able to undertake all the maintenance needs of the buses

21 Do you have a budget for maintenance

22 How long does it take a broken down bus to be restored back to the road

23 How do you make up for a broken down bus on a route

Fares

24 Who fixes the fares for the buses

25 What factors affect the fixing of fares

26 How often is it reviewed, and the last time it was reviewed.

Support

27 Do you receive any subsidy from the Government

28 What support do you get from your stakeholders

29 What support do you get from the head office in Accra

30 MMT is jointly owned by Government and a foreign company, who are they

31 What support do you get from the foreign owners

32 What support do you get from the Government

Challenges

33 Do you have any constraints that hinders your operations