TOWARDS A MORE EFFECTIVE AND EFFICIENT PUBLIC TRANSPORT SYSTEM : A CASE STUDY

by

Dhiren Allopi

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CERTIFICATE

The thesis entitled *Towards A More Effective And Efficient Public Transport System: A Case Study,* that is being submitted by Mr. Dhiren Allopi for the award of the degree of Doctores Technologiae: Civil Engineering of M L Sultan Technikon, Durban, is a record of the bonafide research work carried out by him under my supervision and guidance.

Mr. Dhiren Allopi has worked on the research work for the last three years, and the thesis is in my opinion, worthy of consideration for the award of the degree of Doctores Technologiae: Civil Engineering in accordance with the regulations of the Technikon.

The results embodied in this thesis have not been submitted to any other University or Technikon for the award of any degree or diploma.

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Dr. Ashoke Kumar Sarkar
Transportek
Council of Scientific and Industrial Research
Pretoria

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ABSTRACT

The Government of South Africa has recognised transport as one of its five main priority areas for socio-economic development. One of the Governments strategic objectives, as reflected in the white paper on National Transport Policy, is to promote the use of public transport with the goal of achieving a ratio of 80:20 between public transport and private car usage, as a long term vision. This is no easy task and in order to achieve this goal, an in depth analysis of the current transport situation is required. The structure and land-use patterns of most of the South African cities have forced the residents to be predominantly dependent on private transport, resulting in high car ownerships. Over the years, this has caused the traffic on the major links connecting the suburban areas leading to the city centres to be very high and some of them have already approached forced flow conditions during morning and evening peak periods. In view of this, the transportation problems of Chatsworth, a major suburb of Durban, have been considered for detailed analysis in this study.

Bearing in mind the Governments objectives in terms of promoting public transport, a home interview survey was conducted amongst the commuters in the area in order to establish their attitudes, preferences and priorities concerning the existing transport system. The assessment of the current transport situation shows that the lack of accessibility and the inadequate levels of personal security were the primary causes for the under-utilization of metro rail in the area. With a view to increase the accessibility to the rail system, a methodology has been presented based on data flow diagrams (DFD) for developing a computer simulation model for the operational analysis of minibus taxi-rail integration. The service requirements of metro rail and the minibus taxi service were analysed based on different demand scenarios in order to determine the optimum service requirement for the integrated system. A prototype was also developed based on the methodology suggested in order to determine the feasibility of a proposed solution before investing in the large scale development of the target system. This thesis further discusses a few policy decisions in the form of planning, education and enforcement to attract more commuters to the public transport so that the modal split between public transport and car can be achieved in the long run.

Keywords:

Durban, Chatsworth, commuter, modal choice, public transport, metro rail, minibus taxi, accessibility, transport infrastructure, data flow diagrams (DFD), prototype.

TABLE OF CONTENTS

CHAPTER 3 : ASSESSMENT OF THE CURRENT TRANSPORT SITUATION

CHAPTER 4 : COMMUTER PERCEPTIONS OF THE EXISTING TRANSPORT SITUATION

CHAPTER 5 : DEMAND ANALYSIS OF THE STUDY AREA

CHAPTER 6 : DEVELOPMENT OF AN INTEGRATED TRANSPORT SYSTEM

CHAPTER 7 : DEVELOPMENT OF THE PROTOTYPE

CHAPTER 8 : CONCLUSIONS AND RECOMMENDATIONS

LIST OF TABLES

LIST OF FIGURES

LIST OF SCREENS
(Chapter 7 : Development of the Prototype)

APPENDICES

CHAPTER 1

INTRODUCTION

CHAPTER 1

INTRODUCTION

1.1 Background to the study

In recent years, the emphasis on economic efficiency and the optimum utilization of existing transport infrastructures have featured high on the Government's agenda universally. South Africa is no exception and currently seeking strategies to optimize capacity utilization and to achieve a level of integration among modes. The present transportation problems in South Africa may be attributed largely to the improper city and land-use planning especially during the apartheid era. Most of the major cities are scattered and the suburban areas are quite far off from the city centres with just one or two major road connections. Generally, the areas were allowed to grow as single unit low density developments. Such city structures, with low population densities and scattered commercial and shopping areas were not suited for supporting efficient public transport systems. The suburban areas that were located at close proximity to the Central Business Districts (CBD) of the cities were designed exclusively for the white population and the land-use plan supported multi-storeyed residential complexes. These areas and the CBDs were provided with subsidized public transport systems of reasonably high level of services. However, most of the residents were able to afford private transport and thus car population was high and the transit systems were not fully utilized. The non-white population, whose income levels were low, were mainly located far off from the CBDs and very often the residents had to rely on privately owned buses. Subsidized bus transport were provided to some areas but at a very low level of service. The operators of private buses, naturally, were interested in making profits and thus the levels of service offered were low with very little services available during off-peak periods. Sometimes rail systems were provided in these areas, but without proper planning and without taking local population into confidence. In most cases the stations were located at quite a distance from the residential areas without proper access facilities. Train being a fixed route facility, in absence of feeder services to the stations, were not utilized fully. This kind of situation created wide gaps between the travel demand and transit supply and were partially filled up by increasing car ownership by the residents. With the improvement of the economic conditions of the residents the car ownership level also increased tremendously. However, not all could afford cars and thus the poor were the sufferers being deprived of accessibility to opportunities and facilities.

The introduction of minibus taxis about two decades ago, was hailed as a major breakthrough in providing masses with quality transport with cheap and almost door to door service. The poor accessibility to bus and rail coupled with the unaffordability of a large proportion of the population of owning car, led to a large proportion of the commuters becoming dependent on minibus taxi. However, being under private control, the level of service provided deteriorated quickly. Overloading, reckless driving and reduced frequencies during off peak periods were all contributing factors to the low level of service. Furthermore the escalation in violence, crime and "taxi-war" in recent years contributed to the decline in public transport patronage. Thus the 'craze' for car usage continued and as income level increased, the car population also steadily increased.

The increase in car population and usage has its effects on the roads with traffic congestion, accidents, pollution and driver frustrations. Almost all the South African cities are experiencing these problems. It is true that the condition is not yet as bad as in some of the cities around the world but it may reach that stage unless suitable measures are initiated now. Even two decades ago, some of the American roads were experiencing worst traffic problems. It had been claimed that American drivers waste 2 billion hours a year in traffic jams which resulted in an annual loss of more than 73 billion dollars to the US economy (Gray and Hoel, 1979). A recent study showed that Los Angeles residents wasted an average of 49 hours per week stuck in traffic jams. In Washington, the time wasted in traffic jams equals about 59 hours annually per resident. This translates into a high price tag of about $2.9 billion a year (Moe, 1997)

Keeping the above facts in view, the Government of National Unity decided to review the existing transport policy to meet the transport needs of all South Africans under the changed environment. The process which commenced at the beginning of 1995 involved all the relevant stakeholders. This consultative process also included working groups and plenary sessions which led to the release of the Green Paper in March 1996. Additional comments and feedback were received which resulted in the finalisation of the White Paper. The White Paper on National Transport Policy which was completed and circulated in September 1996 provided a basis for transport to play a more strategic role in social development and economic growth. The White Paper identified the vision of South African transport as a system which will: *Provide safe, reliable, effective, efficient, and fully integrated transport operations and infrastructure which will best meet the needs of freight and passenger customers at improving levels of service and cost in a fashion which supports government strategies for economic and social development whilst being environmentally and economically sustainable.*

The White Paper has placed a lot of emphasis on land passenger transport. The policy was intended to provide guiding principles for all functional levels ranging from national to local government authorities. Marketing of passenger transport policies and services as well as safety and security of passenger transport users were included in the policy framework. The strategic objectives for land passenger transport centred planning, regulatory, operational , funding and customer based aspects. Strong focus was also placed on comprehensive integrated planning. The White Paper discusses the need for regulation and the importance of doing so with an integrated planning process as: *It is essential for land passenger transport planning to be carried out in an integrated fashion covering all modes. This planning should be done at as low a level as possible and by the relevant transport authority. Independent planning by modal operators should be discouraged since the passenger transport plan should be comprehensive and cover all modes and the spatial integration of land use activities.*

In all the major cities in South Africa, namely Cape Town, Durban, Johannesburg and Pretoria, a number of public transport modes operate. They are subsidized buses, private buses, minibus taxis and metro rails. However, they operate almost independently. This creates problems like duplication of routes and under-utilization of infrastructures resulting in huge economic losses and low level of services to the residents. With the current emphasis on optimum utilization of existing infrastructure, this kind of situation cannot be allowed to continue and necessary steps are to be taken to provide integrated transport systems.

In view of the above facts, a study was taken up to understand the transportation problems faced by the residents of a suburban area of a large city of South Africa, which is being served by major public transport modes and then to suggest methodologies to provide an integrated public transport system so that the existing infrastructures are optimally used and the residents get a fairly high level of transit service. Accordingly, it was decided to take up Chatsworth, a suburb of Durban as a case study.

1.2 Study Area

Chatsworth, one of the major suburban areas of the city of Durban, is a typical example of apartheid planning. This area was chosen since it is serviced by all three modes: rail, bus and minibus taxis that operate independently. Frequent congestion and accidents are experienced on the only major access road from the area to the Durban CBD. Observations reveal that the metro rail service is grossly under-utilized. The residents have over the years demanded for a second access road linking the area to the Durban CBD. These are some of the many factors that warrant a full investigation of the current transport situation with a view of suggesting a methodology that will be able to make optimum use of the existing infrastructure.

The study area is situated approximately 26 kilometres (road distance) to the south west of the Durban CBD (Figure 1.1) with a population in excess of 200000 and car ownership of about 40000 (1991 Census). The development of Chatsworth was a "product" of the Group Areas Act. In response to a report on "The Indian Housing Problem" which was released in 1958, the Durban City Council commenced work on the Chatsworth Housing Scheme in 1960. The area was designed primarily as a residential satellite to Durban and its position relative to employment areas provides one of its major advantages. The industrial areas of Mobeni, Jacobs, Clairwood and Prospecton are located in proximity to Chatsworth. The scheme was originally designed to accommodate 160000 people and approximately 22000 units were completed by 1980. The total area of the scheme is in excess of 2000ha. The area (Figure 1.2) is bounded to the north and south by the steep Umhlatuzana and Umlaas valleys respectively and is itself undulating in character. Chatsworth is situated in the South Central Sub Structure of the Durban Metropolitan Area and was one of the first large scale Indian housing schemes developed as a result of the Group Areas Act. While the area is a fully developed township, there are a number of vacant open spaces which exists and are currently investigated for possible housing developments. Over the years, a number of informal housing developments have occurred in and around Chatsworth with minor settlements in the Mobeni Heights and Bayview areas. There is only one major access road (Higginson Highway) connecting Chatsworth to the CBD. There exists a high level of commuting between Chatsworth and the Durban CBD. Hence, It can be observed that the main thrust of movement by the people of Chatsworth is generally towards the area east of Chatsworth.

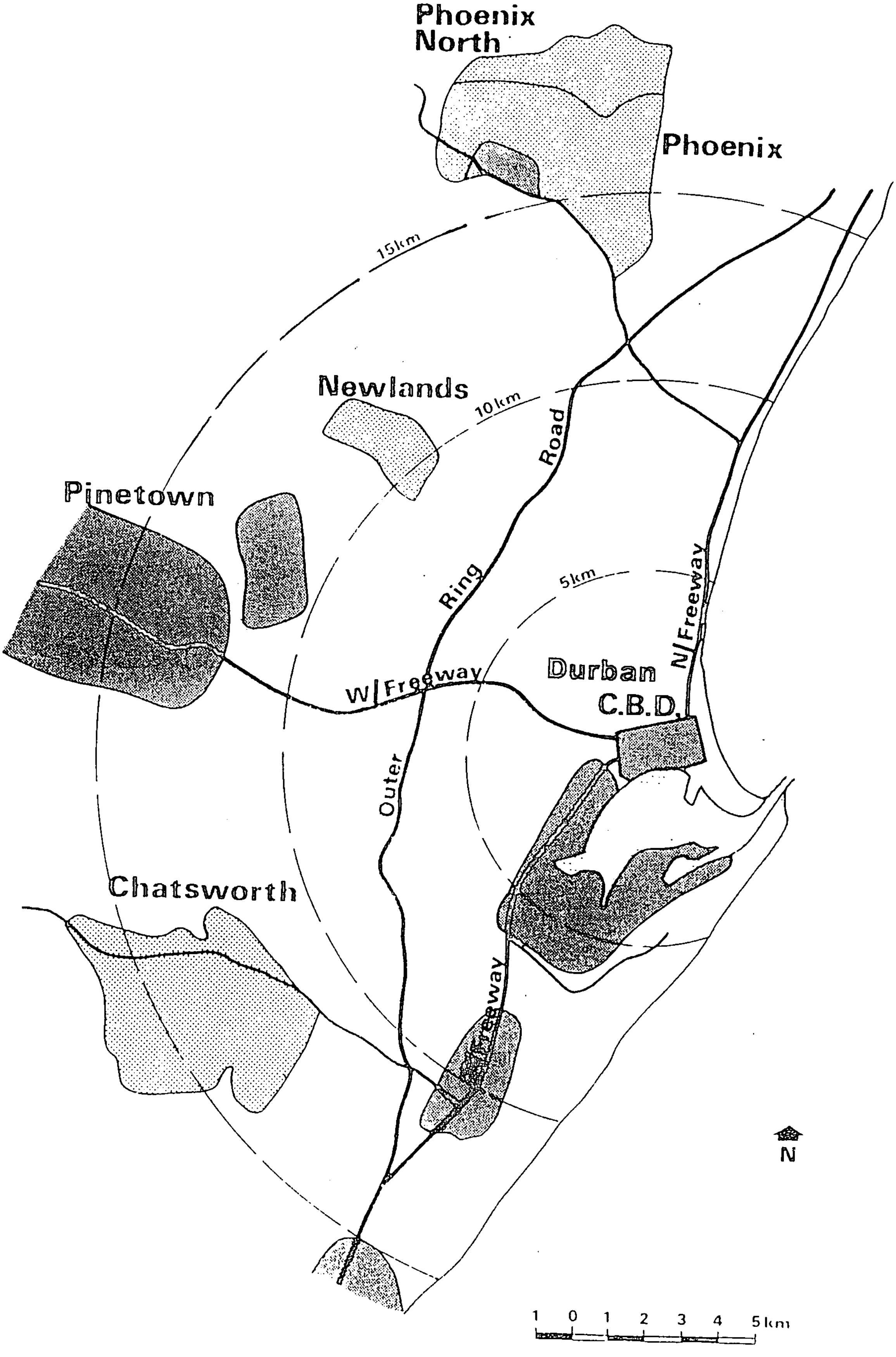

FIGURE 1.1 : Regional Setting : Chatsworth

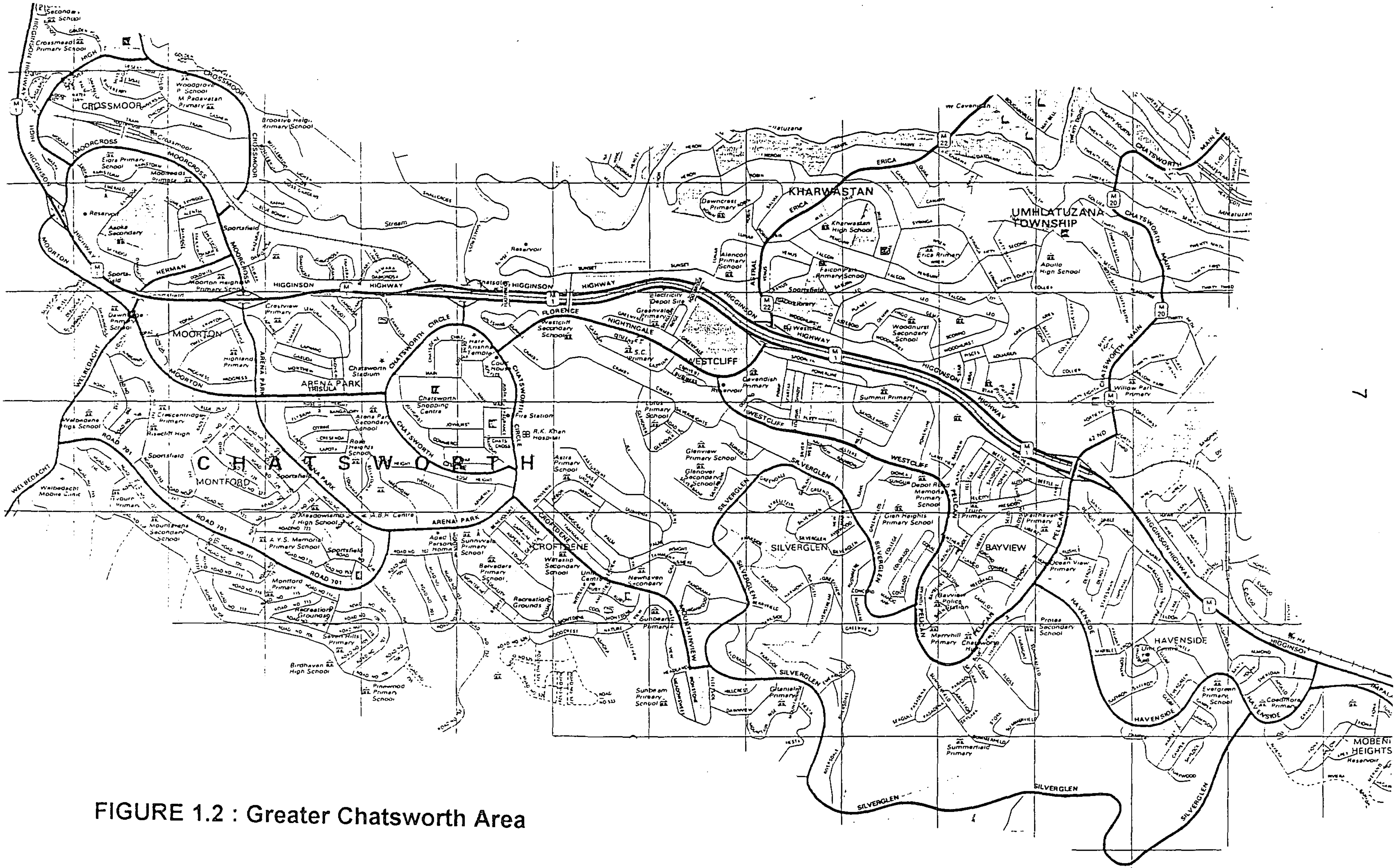

FIGURE 1.2 : Greater Chatsworth Area

The N2 freeway and the road network through the industrial areas, which includes the Southern freeway, are the primary routes via which the people of Chatsworth commute. However, the Higginson Highway is the only link from the area to the N2 and Southern freeways. This area is also connected with an expensive surface railway system (metro rail) which was opened in 1971. The steady increase in car ownership has resulted in the only major access road from this area to the Durban CBD perpetually operating at forced flow conditions during the peak traffic periods. Volumes as high as 4000 vehicles per hour in one direction have been recorded in both the morning and afternoon peaks resulting in congestion, driver frustration, accidents, fuel wastage, noise and air pollution. The am peak hour volume has already increased by 66% since 1988 (2926 vehicles/hour to 4863 vehicles/hour) and there is no indication of this trend being reversed or curbed. This has instigated the residents to demand for a second access road from the area to the CBD.

A study was conducted by Hill Kaplan Scott Incorporated (1982) to assess the need for a second access road to cater for commuter traffic between Chatsworth and the industrial and commercial sector stretching from Mobeni to the Durban city centre. Traffic studies of the Higginson Highway indicated that serious congestion would occur within 10 and 15 years unless steps were taken to handle the anticipated growth of peak hour traffic. The report identified 3 possible routes which were technically capable of solving the Chatsworth traffic problem. The merits and limitations of each route was also discussed. The basic costs of the three routes ranged from R5,90 million to R11,36 million. These were the estimated costs determined in 1982. Obviously the present cost of these projects would be enormous.

Since the area is inhabited by people of different income groups, a substantial percentage of the commuters still rely mainly on public transport provided by privately owned buses and minibus taxis. Surprisingly, the patronage on the metro rail service is extremely low and is decreasing gradually. Rail patronage continued to decline with the drop in patronage since 1983 reaching as high as 83 percent. The recent status quo report (Traffic and Transportation Department, Durban Corporation, 1995) indicates a potential growth in capacity of 265%. This situation is also reflected by the present percentage utilization of the parking bays at four of the five stations which range from zero to three percent. This is a unique situation where, on the one hand, there is a demand to construct a new access road and on the other hand, an expensive metro rail system remains highly under-utilized. *The effectiveness of public transport must be examined to see that it meets the needs of the community. There is currently a Chatsworth rail line, but effectiveness from a community point of view is very low.* These were the comments made by Mr R Moore (executive Director, Physical Environment, City of Durban) at the Public Transportation Workshop on 6 March 1993.

While Chatsworth is a fully developed township, there are a number of vacant open spaces which are not being utilised for recreation purposes. Furthermore, the Parks Department (Durban Municipality) has indicated that it is not in a position to maintain the large amount of open spaces. Many of the sites are in the process of being investigated for possible housing developments. This proposal, if implemented, would certainly add to the population and already high car ownership rate in the area. Therefore, improved management and control of traffic networks could be regarded as a matter of urgency and very often represents the only alternative that could lead to a cost-effective solution to the present traffic congestion problem.

In order to facilitate and increase the use of public transport it is essential that the integration and co-ordination of the different modes of transport be improved. The white paper on National Transport Policy has placed strong emphasis on integration of passenger transport and intermodal transfer. All stakeholders involved in passenger transport agree on the need for the integration of passenger transport to optimise public transport services.

Various factors influence the choice of alternative modes of public transport including, quality of service, accessibility, safety and convenience as well as fares and travel time. The growing taxi network itself will have an effect on rail patronage in this area. If all these factors can be effectively addressed, a shift from private to the public transport is inevitable.

This study coincides with the Government's Reconstruction and Development Programme (RDP) which includes in it's key programme of meeting basic needs, the provision of effective and efficient public transport for all people of South Africa. It is important at this time to respond positively to the challenges of the RDP as it impacts on the public transport industry. Fundamental aspects of public transport operation and control impacting on efficiency and effectiveness of the combined public transport services need to be incorporated in the Passenger Transport Plan.

The white paper on National Transport Policy places strong emphasis on integrating public transport modes in respect of scheduling routes and ticketing systems. It was also made clear in this document that restraint on private car usage will not be implemented independently of improvements in the quality of public transport.

Some of the more important benefits derived from an effective and efficient integrated public transport system include the following:

. Reduction in the use of private vehicles.

. Transfer of passenger demand will be improved on the rail corridor (separate right-of-way and "congestion free").

. Reduction in travel time, from origin to destination, if properly controlled, monitored and operated.

. Reduction in the consumption of fuel by vehicles.

. Reduction in accidents from origin to destination - almost accident free travel on the rail corridor.

. Reduction in air pollution.

. Increase in comfort (new and improved design of coaches)

. Increase in personal safety since more people will be using the system, especially after hours.

This study is expected to assist in solving similar problems in other areas since it is essential in South Africa to have high capacity public transport systems in the large Metropolitan areas. Such services is of vital importance to reduce dependency on private transport, contain traffic congestion, reduce accidents, optimise energy usage, promote positive environmental changes and reduce the need for investment in capital intensive road infrastructure.

1.3 Definition of Terms

It was considered necessary to define some of the more important terminologies applicable to the study. A brief description of some of the terms used are given below:

1.3.1. Capacity

The capacity of a highway may be described as its ability to accommodate traffic; more specifically, the maximum number of vehicles which has a reasonable expectation of passing over a given section of road during a given time period under prevailing roadway and traffic conditions.

With specific reference to taxi, bus or commuter rail transport, capacity may be defined as the number of people a system can carry.

1.3.2. Levels of Service (LOS)

The concept of LOS is a qualitative description of the operational conditions prevailing on a transport facility and how these conditions are perceived by the users. In so far as highways are concerned, LOS is expressed qualitatively in terms of freedom (or otherwise) to select speed of travel and to manoeuvre from lane to lane in order to maintain the selected speed. LOS is also expressed quantitatively in terms of speed, density and volume/capacity ratio.

1.3.3. Accessibility

Accessibility is a function of route location and network design. Not only must a transport system have adequate carrying capacity, but that capability must be placed within a reasonable distance of the intended user. Otherwise, it is as if the service didn't exist. Accessibility is also related to the route flexibility of an individual mode.

1.3.4. Flexibility

Flexibility is the ability to react or adapt to a variety of needs or changing conditions. Flexibility appears in a variety of forms:

(i) Volume: Certain modes handle large volumes of traffic efficiently eg. railroads have wide volume flexibility.

(ii) Commodity: Passenger traffic differs principally in requirements involving volume, speed, time and comfort.

(iii) Route flexibility: The ability to travel directly from any given point of origin to a given destination.

1.3.5 Frequency

Frequency is expressed by the number of vehicle departures per unit time (generally one hour). Short, regular frequencies are essential in attracting commuters to public transport.

1.3.6 Reliability

This may be expressed as a percentage of vehicle arrivals with less than a fixed time deviation from the schedule/time-table (eg. 5 minutes). Reliability depends on factors such as adherence to schedules, low breakdown rate, quick "back-ups" in the event of a breakdown and sufficient information about any changes to the service.

1.3.7 Comfort

Comfort is a rather difficult concept to define since it encompasses many qualitative factors. Various elements including overcrowding, availability of a seat, physical comfort of the seat itself, presence of air conditioning, noise levels, etc. will all have an impact on the comfort factor. "Comfort" embraces the physical comfort of the commuter within the vehicle and at stops, the aesthetic qualities of the system and the environmental protection of the community.

1.3.8 Integration

According to Roberta Remak (1979): *System integration is essentially a management technique applied to a group of functions that are currently being administered independently, but are in fact highly interdependent and could be managed more effectively by being treated as interrelated parts of a single system.*

With reference to public transport, *integration* refers to the creation of a public transport system which is seen as a single entity or a homogenous unit irrespective of ownership.

1.3.9 Co-ordination

Co-ordination relates the mutual co-operation of a more effective relationship between different levels of government, land-use and transportation planning and the administration of public passenger transport. In general, co-ordination refers to the mutual co-operation or bringing together the different elements or parts of a transportation system to encourage/enhance interaction amongst them.

1.3.10 Minibus taxi

The word "taxi" for the purpose of this study refers to a minibus taxi which provides, at this stage, an unscheduled public transport service and is authorized by a permission.

1.4 Objectives of the Study

This study intends to assess the current transport situation in Chatsworth, a suburban area of Durban, which is being served by major public transport modes, and suggest a methodology to optimally use the existing infrastructures.

To fulfil this goal the following study objectives have been set:

(1) To assess the current transport situation in the study area, which includes the traffic characteristics of the existing link connecting the CBD; the available infrastructure, facilities and services pertaining to all the public transport modes serving the area; and the problems experienced by owners and operators providing public transport services.

(2) To determine the perception of the commuters with regard to the present traffic condition in the study area, their preferences of modes with reasons and their expectations on the level of service of public transport modes.

(3) To study the service requirements of the existing Metro Rail and minibus taxi services in the study area with different demand scenarios. This will help determine the optimum service requirement for the integrated transport system based on the employment demand.

(4) To develop a methodology for the integration of public transport modes.

(5) To develop a prototype based on the methodology on integration so as to determine the feasibility of a proposed solution before carrying out a full scale study. The development of the prototype will include the implementation and testing of screens using set test data.

(6) To suggest broad policy guidelines and recommendations to make public transport attractive.

1.5. The Data, their Treatment and their Interpretation

The data for the study was basically of two types: primary and secondary data.

The primary data was obtained from the assessment on the current transport situation and responses/feedback from a representative sample of the three public transporters and commuters in the study area. This was supplemented by data obtained from the Traffic and Transportation Department of the Physical Environment Service Unit (Durban Corporation), Metro Rail and Central Statistical Services.

Secondary data included published papers, research reports and texts, unpublished dissertations and thesis. Articles and reports published by leading newspapers, various research institutes, Government departments and professional bodies associated with transport (South African Institution of Civil Engineering; Department of Transport; Transportek, CSIR; Chartered Institute of Transport in Southern Africa; etc.) were also referenced.

1.6 Research Methodology

The data of this study is both qualitative and quantitative and the descriptive survey method was used in this study. Leedy (1993) has said that the nature of the data should dictate the research methodology that ought to be employed in the processing of the data. The technique of observation and interviews as a principal means of collecting data was adopted to determine level of service, accessibility, frequency of service, adequacy of facilities/infrastructure, commuter attitudes, preferences and priorities concerning the existing transportation situation and a host of other factors. This was supplemented by data obtained from traffic and transport surveys undertaken by the Durban Physical Environment Service Unit and Metro Rail.

A coded semi-structured questionnaire was designed and quality tested for precision of expression, objectivity, relevance, suitability to the problem situation and probability of favourable reception and return. Research assistants and in-service students were engaged to conduct the selective interview process. To ensure that the responses obtained be fairly representative of the population, a random sampling technique was adopted.

The data analysis was carried out on a personal computer using the Statistical Package for Social Scientists (SPSS). Frequencies tables were first generated based on the responses obtained. Using a function called "cross-tabs", it was possible to determine a host of relevant combinations of the variables eg. family net income vs number of family members in household; family net income vs occupation of respondents vs mode of transport; number of cars in household vs mode of transport; monthly expenditure on transport per household vs mode of transport; etc.

The final bar and pie graphs were completed with the aid of a spreadsheet package. These graphs indicated, for example, the main modes of travel, occupation of respondents, public transport modal split, commuter opinions on:

quality of service, adequacy of facilities/infrastructure, safety, time spent walking to the nearest bus/taxi stop or station, etc.

A computer aided design (CAD) package was used to present a methodology based on data flow diagrams for developing a computer simulation model for the operational analysis of minibus taxi-rail integration.

A prototype was developed based on the methodology suggested. The development of the prototype with input/output screens included the analysis of the data flow diagrams, structuring and programming of screens as well as the implementation and testing of screens using set test data.

1.7 Overview of the Chapters

Chapter 2 provides a review of some of the literature available and related to the research area. The review of the related literature was discussed under three sections, namely, the decline in public transport, the need to improve public transport and some of the management techniques that have been recommended in favour of public transport.

Chapter 3 discusses the assessment on the current transport situation in the survey area in order to identify possible reasons for the decline in public transport, especially the metro rail system. The steady increase in the number of vehicles over the years on Higginson Highway was highlighted. The available facilities and infrastructure pertaining to bus, minibus and rail were also recorded. The gradual decline in rail patronage in recent years was emphasised.

Chapter 4 outlines the survey that was conducted amongst the residents in the survey area in order to establish their attitudes, preferences and priorities concerning the existing transportation situation. Information pertaining to their socio-demographic profile, mode of transport, and feedback from private car users and public transport users were obtained and recorded with the aid of tables and figures. Various software packages were used in the analysis and presentation of the data.

Chapter 5 demonstrates the sensitivity of the integrated system proposed for the survey area with regard to population, employment, capacity, frequency of service and various other elements that may impact on the system. Vehicle capacity of both the rail and the minibus taxis were discussed in detail. The level of demand during the peak period was used to calculate the peak fleet requirement for both modes.

Chapter 6 looks at the concept of integration and the various factors that need to be considered when applying the concept of an integrated passenger transport system. An attempt has been made in this chapter to suggest a methodology based on data flow diagrams (DFD) to integrate the rail with the minibus services. The various components of the data flow diagram are explained and the stages involved in the development of the data flow diagram are discussed in detail. The context diagram, top level data flow diagram (Diagram 0) and the detailed level DFD for two of the processes on diagram 0 are also shown.

Chapter 7 reflects the stages in the development of a prototype model following the methodology based on the data flow diagrams in the previous chapter. The tools and procedure adopted in the development of the prototype are discussed. The steps required to run the programme are also listed. Finally the cost analysis for a few proposed options are presented.

Chapter 8 discusses a few additional suggestions in favour of public transport and especially to make metro rail attractive. Recommendations relating to safety, marketing, revamping of stations, transport funding, rail concessioning, public education and upgrading of existing facilities and infrastructure were some of the many factors discussed in order to attract more commuters to the public transport so that the modal split of 80:20 between public transport and car can be achieved in the long run.

CHAPTER 2

THE REVIEW OF THE RELATED LITERATURE

CHAPTER 2

THE REVIEW OF THE RELATED LITERATURE

2.1 Introduction

The steady decline in public transport and the high car usage in many of the urban and suburban areas in South Africa is a major cause of concern especially when the Government of National Unity intends to increase the share of public transport usage substantially. The existing literature has been reviewed in this chapter to understand the reasons for increasing use of cars and decline of public transport systems in general. The available literature on transportation systems management and modal integration have also been included to know and compare the techniques used worldwide to make public transport attractive, which will help to develop a methodology on modal integration in the South African context.

2.2 Literature Review

The literature review uncovered three distinct sections that had an influence on this study. The first section dealt with the decline in public transport and the many factors contributing to this decline. The review also looked at some of the factors that made the private car so popular and how the introduction of the automobile undermined the market of interurban rail service. The second section dealt with the need for improving public transport systems. The problems associated with traffic congestion was emphasised by many authors. The present demands that have been placed on the existing urban transport system was also highlighted by some of the authors. Many of the comments were directly or indirectly related to the current environmental crisis experienced in many parts of the world. The third stage of the review looked at the possible steps or solution to solving the current transportation problem. Various traffic and transportation management techniques were discussed in an attempt to improve public transport with varying degrees of success. It may be noted that not many South African references were available on the subject and it was also necessary to look at international trends with regard to the study. A brief account of the review of the literature in these three areas is given in the following paragraphs.

2.2.1 Historical Overview : Public Transport Decline

The SELNEC transportation study (1973) carried out in greater Manchester during the 1960s indicated that the operating environment for public transport was steadily declining. Increasing car ownership and changed social habits reduced demand and traffic congestion became an everyday feature of urban life. It has been *reported: The main cause of the congestion and the decline in passenger numbers is the growing use of the private car. For every 10 cars in the Transport Study area in 1966, there are expected to be 25 by 1984, and this is a conservative forecast. The roads cannot be improved to contain all the cars, except at appalling cost in money and in damage to the towns they would dominate. If cars take over towns, travel will become intolerable and the economy of the area will stagnate.*

According to Farris and Harding (1976), many factors have contributed to the popularity of the motor car in the United States and throughout the world. These factors included convenience, symbol of power, wealth and speed, privacy, comfort and security that could not be duplicated by other modes of transportation. The automobile also brought individual mobility and a sense of freedom to large segments of the American population. Farris and Harding also discussed the increase in mass transit ridership during the war which was mainly due to the governmental restrictions on the operation of private vehicles. There has since been a steady deterioration of facilities and ridership despite rapid population increases in metropolitan areas brought about by high birth rates and migration from rural regions. Amongst the many factors contributing to this decline included the substantial increase in the cost of operating the systems, short-run productivity increases to offset increased costs have been difficult to produce because of right-of-way limitations and the "peak load" problem, revenue loses and the general lack of regional transportation planning.

Prestwood-Smith (1977) traced the historical record of transport planning in Britain. He acknowledged that whilst many of todays transport problems stemmed from the more recent growth in use of the private car, these problems had their origin in the growth of urbanisation, generated by the industrial revolution. Motor vehicles grew from under half million to over three million between the two world wars or the local authorities responded to the increase in congestion by capacity increases through road widening and improvements. Early Post War government policy for transport, which had been to encourage economic growth through the reduction of transport costs by the provision of an inter urban motorway system, did not solve the urban transport problem. Growth in traffic exceeded expectation, public transport patronage dropped following the increased use of the private car and the drop in urban population densities. Only the planners started to look for more thorough and comprehensive ways of assessing the needs for transport.

Hay (1977) discussed the development of transport before, as well as after 1900. He also highlighted the decline in public transport in the United States, especially the dwindling rail passenger traffic to an extreme low in 1970. The automotive age was clearly demonstrated by Hay reflecting 55000 cars by 1904 and 5.5 million passenger cars by the end of world war 1 in 1918 with registration increasing to more than 93 million passenger vehicles in 1977.

According to Gray and Hoel (1979), even before the automobile revolution in the United States, the transit industry was seriously weakened by financial peccadillos, stock jobbing, unscrupulous promoters, and a host of other practices that left the viability of large segments of the transit industry in a financially embarrassed and weakened state. The high cost increase during World War 1 and interest due on over-inflated capitalization, together with limitations on the amount of fare that might be charged and other statutory obligations connected with operating franchises, led to the bankruptcy of a major portion of the transit industry by 1918. The decline in ridership, which was due to the increased availability of dependable automobiles at reasonable prices, cut revenues and made transit less and less attractive. Instead of serving all types of trips, public transport became the preferred mode only for the journey to work, and then gradually lost predominance in this area, being largely replaced by the private automobile for every type of trip. Only those that had no other choice used public transport and competition from the automobiles was cited as the main reason for the decline in public transport.

The Confederation of British Road Passenger Transport (1981) stated that for many years policy documents on urban transport have mentioned the need to improve public transport. Yet, surprisingly only few have offered specific advice on how to achieve improvement and the general scene in London was still one of decline. Although some formal advice had been offered by the Department of Transport there was still no single document setting out the basic characteristics of and requirements for a good public transport service.

Paquette et. al. (1982) noted the long-term secular decline in rail passenger traffic in the United States from 24.2 billion passenger miles in 1929 to a low of 4.3 billion passenger miles in 1972. During the 1950s and 1960s the rail roads problems persisted and grew worst. The industry's share of the total transportation revenues declined from 56% in 1955 to 34% in 1970.

Bruton's (1985) predictions were that the major transport problems of the near future would be in the suburban areas due to the present high rates of residential and employment growth. He said that it was reasonable to assume that the growth in demand for travel by the motor vehicle would approximate to the growth in households which would almost certainly exceed the rate of population growth. Severe difficulties were experienced with public transport which included increased operating costs, declining levels of patronage and the declining levels of service. He added that transport planning in the future had to focus on a range of problems which could have been avoided in the past if land-use and transport planning were integrated.

A World Bank Policy Study on Urban Transport (World Bank, 1986) looked at the crisis in public transport and discussed how only few public transport systems in the developing cities were able to keep pace with the rapid and substantial increases in demand over the past few decades. Public transport deteriorated and their efficiency and output was further reduced as passengers turned to private cars and thus added to traffic congestion. Discussions also centred around the steady increase in household income which resulted in a marked increase in car ownership. This was explained partly by an increased demand for quality transportation (speed, comfort, privacy) and partly by the failure of public transport systems to provide satisfactory service.

Tobia (1990) said that several studies were carried out in an attempt to identify the causes that had contributed to the configuration on the evolution of the urban transport problems of Caracas. The first and most noticeable factor was that of the physical restrictions of the city settings which included the shortage in space available for transport uses. The second factor was due to the insufficient transport provision which resulted from the inflexible road network structure and the lack of good public transport both in quantity and quality. The third factor was related to the relatively high and unequally distributed car ownership rates and the consequential high levels of car usage. Tobia said that this system had taken a huge part of the transport space, which was socially and economically disproportionate when compared with the volumes it moved. He further added that this had a detrimental effect on other modes, more efficient as far as the relationship between space consumption and capacity offered was concerned. Another factor, also cited, was the lack of comprehensive traffic management techniques. The last factor was related to the legal and institutional situation with regard to conflicts of competence between central and local governments.

At an informal discussion regarding research needs in transport held at the conference organised by the Institute of Civil Engineers (Thomas Telford, 1993), Mr Gore, one of the introducers, explained that the increasing incidence of congestion during the 1980s was instrumental in placing transport on the political agenda of the 1990s. Pressures concerned with the quality of life, the risks associated with global warming, and environmental concerns were also seen as key political issues. He pointed out that in the UK the passenger transport data revealed a picture dominated by an excessive growth in car ownership and, more significantly, in car usage. With regard to transport demands, Dr Heyes, one of the introducers, pointed out that despite the fact that todays problems were largely forecast some thirty years ago, it was only now that it was becoming accepted that demand would need to be managed. He added that high car usage was largely responsible for traffic congestion, environmental concerns and most of the carnage on our roads.

According to the Interim Transportation Plan (1990) for the Durban Metropolitan Transport area it is stated that the car ownership rate is increasing rapidly among Indians. The report showed that public transport users were confined almost exclusively to non-car owners, implying that access to car ownership among Indians has been responsible for the relative reduction in public transport trips and the massive rise in trips by car. A high percentage of Indians are located in the Durban and surrounding areas.

Harrison (1995) discussed how the introduction of the automobile in the early part of this century undermined the market for interurban rail service which also led to the disappearance of the nation's trolley system in the 1950s. He observed: *Automobiles provide a freedom of movement unequalled by public transport, but at a huge cost - monetarily and environmentally, and in terms of loss of life, injuries, and property damage from accidents.* Harrison further stated that the Americans realized that it was not possible to continue expanding the highway systems to solve the traffic jams that were so common in the major urban corridors. He also highlighted that auto usage had been largely responsible for making the air unhealthy in many U.S. metropolitan areas. Americans still did not realize the full cost of relying so heavily on automobiles.

2.2.2 The Need for Improved Public Transport Systems

Dickson (1976) said that it was said that South Africans had to learn only from their own mistakes, even though it was cheaper to learn from somebody else's. According to him, the only cities in the world whose buses were faster than cars, and indeed the only ones which have wooed people out of their cars, were those which provided preferential road space for buses on an ambitious scale and also actively discouraged a surfeit of cars from entering busy areas. He added that the removal of kerbside parking space would gain an additional traffic lane in which an unbelievably large number of people could be conveyed if it was reserved for buses. He further emphasized that means must be found to move the greatest number of people in the most efficient way (which was not the same as moving the greatest number of vehicles) with the least manpower and as quickly as possible. He added: *Every additional car which contributes to congestion on our peak hour roads is adding to the delay of hundreds of people in buses who cannot afford cars, and whose late arrival at work means hundreds of hours in lost production time. Every additional metre of roadway built to accommodate these extra car drivers, without making special provision for* *buses, is of no assistance to the much greater number of people in the buses - in fact, it encourages more cars which further slows them down.*

Ferris and Harding (1976) acknowledged that the private automobile was the most flexible and convenient means of travel and that our "love" for the automobile did lead to a host of problems. Pollution was sited as one of the problems that threatened the health of urban residents. The aesthetics and beauty of many cities throughout the world were becoming blurred as a result of automobile exhaust fumes. In an attempt to provide more roads and parking facilities, scarce urban land was being used to try and solve the problem of congestion. It was also estimated that approximately 85% of the downtown area of Los Angeles was directly or indirectly devoted to automobiles. Energy shortages and increases in the price of crude oil charged by the oil producing nations caused serious economic problems in the United States and throughout the industrialized world. This crisis in energy was traced, among other factors, to the increase in motor vehicle usage. The motor vehicle usage that swept the United States several decades ago was repeated in Western Europe and Japan which resulted in increased competition for limited supplies of fuel. A long period of abundant low-cost energy came to a rather abrupt halt. Other major economic costs reflected were the construction and maintenance of highways and motor vehicles accidents which accounted for almost half of all accidental deaths in the United States. Ferris and Harding made no exception to the following comment:
It seems clear that if we weigh the disadvantages of heavy reliance on the current generation of private vehicles in urban areas and the continued growth of the highway and freeway systems against the advantages and conveniences of the automobile, we are compelled to conclude that alternative solutions must now seriously be considered.

Stopher and Mayburg (1976) attempted to illustrate the value of time savings and its importance in the development of an economic - evaluation method for transportation projects. They looked at travel time spent during business hours in terms of value or worth to the employer. This was also related to the Gross National Product (GNP), ie. reduction in travel time should increase productivity and thus lead to an increase in GNP. Stopher and Meyburg further discussed the social value of time that could be saved in travelling as a result of a systems improvement. They also explained how the value of travel time was used to produce estimates of travel volume from which the total travel - time changes were computed. This obviously resulted in a substantial portion of the user benefits in the evaluation. They concluded that the use of travel - time values as a means to determine the monetary benefits of transportation improvements was an essential one in economic evaluation.

Hay (1977) emphasised the challenging problems that were faced with in terms of providing an effective transportation system and was capable of moving people in their large numbers. He also added that the population growth was placing increasing demands on transport capacity. Hay said that efforts should be directed towards increasing speed and thus reducing travel time. He further stressed that it was important and necessary to reduced travel times since many cities were expanding outwards thus engulfing suburban and intermediate communities.

Prestwood-Smith (1977) looked at the future objectives for transport policy and observed that : *With public reaction to urban motorway construction and increased political attention to housing, emphasis in transportation planning has turned strongly towards public transport as a solution to the problem of travel, particularly peak period travel, to central areas. It had long been accepted that demands for journeys to central areas were far beyond the capacity of any conceivable road plan and that future travel to central areas would continue to rely on public transport services. It was also recognised that increases in road capacity through road and junction improvements brought with them environmental disbenefits. Control of central area car travel therefore had been accepted practice or some time. This argument has now been extended.*

If central area car travel could be reduced by improvements to public transport as well as increased restraint measures, this would release road space in inner areas giving better operating conditions and attracting more passengers to public transport services and bringing environmental relief to inner residential areas.

OECD (1977) discussed the changing perceptions with regard to urban transport planning. The adverse impacts of transport policies which encouraged greater use of private motor vehicles emerged as an important issue. Noise and air pollution impacts along with the consumption of urban land were the main causes of concern. In many cities throughout the world entire freeways plans were abandoned, mainly on the grounds of adverse environmental and community impacts. Another issue that also emerged was related to the quality of the transport services available to the various socio-economic groups. The increase in car-ownership which resulted in the rapid increase in mobility of the population led to increased spatial specialisation of activities. Location decisions were based on primarily on the accessibility of destinations to car users. These changes obviously led to the decrease in accessibility to activities for those groups without access to a car. It was agreed that a much broader spectrum of options must be considered with regard to the formulation of a transport policy. Options that need to be considered included the provision of services for the handicapped, short - run improvements to bus services, greater integration of road and public transport services and more innovative use of existing transport technologies.

According to Carter and Homburger (1978), traffic accidents constitute one of the major public health problems. Their occurrence indicates a failure by the road facility, vehicle and vehicle operator separately or jointly.

The importance of transport was rightly pointed out by Gray and Hoel (1979) as:
The new interest of state, local, and federal governments towards public transportation improvements has enhanced the transit industry's importance.

The industry is being asked to cope with the nation's need for improved mobility and overall quality of life in U.S. cities, and for reduced automobile use in order to protect the environment and cut the demands of transportation on scarce energy resources. In short, there is a vital need to strengthen transit management and to bring transit into line with modern concepts of management in order for it to meet new and important roles into which it has been cast. It was also stated that the U.S. Department of Transport made every effort to provide highway facilities to meet the apparently limitless demands of the private motorist but in vain. This was a classic example of supply tending to create it's own demand. Concern was expressed with regard to pollution of the environment and shortage of energy and the need to apply incentives to encourage use of public transportation

The overwhelming nature of the urban transport problem sometimes tempted governments to try and solve it by spending vast amounts of money on subways and complex highway infrastructure. These capital intensive projects, however, was not always cost-effective. The World Bank Policy Study (World Bank,1986) on Urban Transport believed that three principles - economic viability, financial viability and efficiency could be used to guide the development of urban transport policies. Economic development and population growth resulted in the enlargement of urban areas and the need to extend the road network and transport services. This involved major investment and a considerable burden on city resources. Cost should be kept to a minimum by establishing suitable incentives for a given quality of services; similarly, the maximum quantity of services should be provided for a given cost. Improved public transport and more efficient management of demand can help to combat the trend away from public transport vehicles towards greater use of private cars.

Latchford (1986) highlighted the rapid growths in size, population and demands for travel in major cities in Developing Countries. He looked closely at two large cities, namely Cairo and Bangkok with regard to the need for traffic management implementation. He added that the rapidly growing population and growing personal incomes had led to a growth in car ownership of 17 % per annum. The completion of a number of major new roads in recent years did not have any impact on the ever increasing travel demands . Congestion was very severe and driving habits were poor. In an attempt to change the trend, the Cairo Government embarked on a policy of priority to public transport and implemented a series of traffic management measures aimed at improving the efficiency of existing transport infrastructure. Latchford also looked at the growth in car ownership in Bangkok which increased from less than 100 000 vehicles in 1960 to 700 000 motor vehicles in 198. Bangkok, like Cairo, had a reputation for severe traffic congestion which involved many hours of wasted time for the residents, considerable waste of scarce fuel resources and a deterioration of the environment through air and noise pollution. Considerable efforts were made to determine the feasibility, role and effect of an appropriate segregated mass public transportation system.

The Institution of Highways and Transportation (1987) stated that some of the world's cities have attempted to design urban areas to accommodate the increase in private cars by constructing massive urban motorway networks at very high capital expenditure and an abundant supply of land. This has resulted in approximately one third of urban land area been given over to roads, parking lots, service areas and other transport infrastructure creating an enormous impact on the environment.

According to ITE (1987), congestion was still experienced with accidents and pollution now endemic social problems with serious economic consequences. The initial concern with air quality was due to the smog alerts experienced in Los Angeles in the 1950s and 1960s. The air pollution problems was closely related to the characteristics of use of the private cars. The frequency of stopping and starting due to traffic congestion had a significant effect on hydrocarbons and carbon monoxide emissions. With regard to highway safety it was found that passenger automobiles had the highest percentage of fatalities.

Chari and Ramamoorthy (1989) highlighted the present demands that have been placed on the existing urban transport system in India due to large scale urbanization and the rapid growth of vehicle population. The sharing of limited right of way by the various modes and other utility services in most cities resulted in traffic congestion, inadequate parking area and environmental deterioration. Due to the existing mass transportation systems having very poor level of service on all fronts, there was a phenomenal shift to personalized modes of travel. This was evident by the increase in vehicle ownership and growth rates in India. The growth of individual vehicles aggravated the problem of traffic congestion, environmental pollution, road safety hazards and resulted in high energy consumption. Mass transport of urban commuters by bus or train on major corridors whereby the people can be transported in large numbers with limited vehicles appeared to be the only way to cope with the situation.

Roy (1989) transit planning, in particular planning of transit restructuring, received very little attention in India and various reports revealed that transit restructuring design was not usually done on a basis of systematic planning analysis. CBD's and other key areas of large cities suffered from congestion and crowding and the travel speed of ordinary bus transit in peak period was gradually declining . The scope for creating new road network was also limited because of resource constraints. Tow felt that a rapid rail transit system would prove to be most effective since it provided the highest transit capacity with high speed and high level of service. He also added that the expansion of facilities and extension of services seldom happened on the basis of a planned transit structure but occurred in "bits and pieces," mostly in response to vocal public demand. When a new major transit facility, like metro rail, was proposed for a city, it was only logical to plan the reorganisation so that the new system can be integrated fully with the existing system to achieve maximum commuter benefit. However, this was seldom done. Roy further commented that the maximum utilization of a high capacity rapid rail system needed to be supported and supplemented by a more flexible surface transit system (eg. buses) to form an integrated total transit system.

Mannering and Kilareski (1990) also highlighted the alarming rate at which traffic was growing. Recent studies showed that traffic congestion, already considered unbearable by many, was forecasted to grow substantially in the future. They said that the projected growth in congestion was a serious detriment to the goal of providing higher levels of service. It was obvious that the current economics of highway construction prohibited any large - scale construction program aimed at increasing roadway capacity. They added that the private vehicle was such an overwhelmingly dominant choice that travellers were willing to pay substantial capital and operating costs, confront high levels of congestion, and struggle with parking - related problems, just to have the flexibility in terms of travel departure times and destination choices. Another important trend, in terms of congestion mitigation was the on going decline in the already low vehicle occupancy rate. This further presented the civil engineering profession with a classic dilemma in striving towards its goal of providing higher levels of service. Mannering and Kilareski suggested that the development of programs that encouraged travellers to take public transportation modes or programs to increase vehicle occupancy would relieve traffic congestion on highways and provide highway users with an improved level of service.

Sullivan (1990) quantified the relationships between accident rates and congestion on California urban freeways. He analyzed data for a number of freeway sections in the San Francisco Bay area. Numerous alternative accident-model specifications were developed and tested. Accident rates were compared under conditions of queuing and no queuing and for a variety of geometric and traffic conditions. It was found that in the presence of queuing, the average accident rate was about two to three times higher than the rate when there was no queuing. The objective of his study was to quantify the relationship that existed between mainline freeway congestion and accident rates so that this relationship could be used by the California Department of Transport in the economic evaluations of proposed freeway improvements and other congestion - mitigation measures. Hence any freeway improvement project that reduce congestion also generally result in reduced accident rates.

According to ECMT (1990), air pollution is caused by a wide variety of man-made and natural sources with fuel combustion been identified as the largest single contributor to air pollutant emissions. Direct emissions from motor vehicles include emissions from exhaust pipes, blow-by from the engine crank case, fuel evaporative emissions from the fuel tank and the carburettor and emissions caused by the wear and tear of tyres and brakes. Air pollutants emitted from gasoline-driven vehicles include carbon dioxide, carbon monoxide, hydrocarbons, nitrogen oxides, lead, ethylene dibromide, ethylene dichloride, formaldehyde and other aldehydes. When emissions from the transport sector are compared to overall man-made emissions on a natural basis, it can be seen that mobile sources causes more than 50% of total emissions. A major portion of overall health effects resulting from air pollution can therefore be attributed to the transport section, and mainly the road transport sector. The negative effects of transport activities mainly included accidents, congestion, air pollution and noise due to road transport. One of the factors that limited the effectiveness of exhaust emission regulations was the continuing growth of motor vehicle traffic. There had been considerable growth in recent years and the trend is expected to continue.

Faulks (1990) indicated that if car ownership continued to increase at its present rate then the time must come when, in those places that are already heavily congested, neither the money nor the space will be able to construct highways adequate for the demands that will be placed on them. If restraints on private cars are imposed, then a very high standard of public transport must be provided if commercial activities within cities is to be maintained. Faulks felt that the high standard of public transport could take the form of a fully automated underground railway system. He also added that much of the present problem, eg. the proliferation of the private car, is due to the lack of proper control.

Macpherson (1993) emphasized that transport was one of the major causes of the environmental crisis. Virtually all vehicles burnt fossil fuels, either directly or indirectly. He said that the main categories of substances emitted by burning fossil fuels included carbon monoxide, carbon dioxide, sulphur dioxide, oxides of nitrogen, smoke particles, organic compounds and lead. Macpherson added that 88 % of UK emissions of carbon monoxide came from road vehicle exhausts with 48 % of UK emissions of oxides of Nitrogen also coming from road vehicles. It was clear from the figures quoted that a reduction in the amount of noxious substances from road vehicles would lead to a significant improvement in environmental quality.

According to the Interim Transportation Plan for the Durban Metropolitan Transport Area (1990): *Good public transport is essential to cater adequately for the demand and to stem the shift from public to private transport. Unless this shift can be halted, an enormous burden will be placed on the road network necessitating additional costly road projects. Furthermore, the public participation programme demonstrated the extreme dissatisfaction of Blacks, Indians and Coloureds with public transport.*

A survey conducted by Kantilal (1996) on the Minibus Taxi Association in the Overport area in Durban found that only 22 % of the vehicles owned were relatively " new " or recent models. It was revealed that a high percentage of the vehicles were uninsured. This was primarily due to insurance companies selling "high risk" policies for such vehicles operating as mini-buses. The political, social and economic environment within which mini-buses operated, resulted in high rates of hijacking stealing and accidents. She also found that none of the employers that were interviewed registered their operators which resulted in a high staff turnover. This was confirmed by the operators that were interviewed. Many of them were in employment for only 1 - 2 years. It was further also revealed that the only requirement that the majority of the operators had to fulfill in order to qualify for the job of a public minibus operators was to produce a legal and valid driver's licence. Other factors that needed urgent attention included the poor condition of some of the vehicles, overloading, lack of facilities / infrastructure and poor working conditions.

Attaluri et. al. (1997) looked at more accurate estimates of demand for planning, designing and operating public transit systems. Two separate models, one for fixed - route and another for demand - responsive services were presented. They focused on rural regions with regard to economic growth through enhanced personal mobility and accessibility to employment markets. It was acknowledged that an efficient public transit system could open up labour markets and enhance the mobility of disadvantaged groups that have been isolated due to lack of transportation. However, they also emphasized that efficiency could only be achieved through good planning and operating practices, which in turn require reliable estimates of demand and an in-depth understanding of needs. As far as planning was concerned, it was confirmed that very little progress had been made in developing tools for estimating demand, establishing routes, and preparing schedules or operating frequencies. They also added that the growing need for transit amongst different groups in rural regions have elevated the demand for flexible and reliable techniques for estimating demand.

2.2.3 Transportation System Management (TSM)

According to Ferris and Harding (1976), the focus of transportation would be on the movement of people in urban areas with the revival of rail passenger service being part of the larger energy - conservation program. They felt that the railroads would probably become the major regional carriers of people and their operations would reflect the service styles and standards of the airlines. The integration of all modes of urban transport into one operational system would be an important outgrowth of energy related research and experimentation. The emerging systems would have freight as well as passenger carrying capacity, thus reducing the total number of vehicles on city streets. Highways would continue to exist, although continued freeway development would probably diminish with highways serving more intercity buses. As a result of energy concerns, political institutions would become more responsive to transportation needs. There would be philosophical changes in transportation regulations that would encourage intermodal and intercarrier cooperation. Unification, integration and co-ordination of the entire system would be stressed. These were some of the comments that revealed the authors optimism about the ability of the nation to solve the transportation problems, energy related and otherwise, and in its future ability to transport people in an efficient and pleasant way.

One of the methods of reducing capacity requirement in solving large scale mathematical programming problems is to decompose the original problems into a collection of interrelated subproblems that are to be optimised. Hsu and Surti (1977) presented such a decomposition approach to bus network design which was accomplished through the optimization of a series of subproblems. A number of bus routes are first determined, the origin and destinations of potential routes identified and the optimal alignment connecting the route origin and destination were located. The size of the network was further reduced by the macromodeling of bus networks at the district level. One of the advantages of the decomposition approach was its interactive capability of incorporating a planners experiences into the design process. The following steps was recommended in the application of the proposed framework:

1. Obtain a preliminary table of trip distribution for a given highway network and land-use pattern.

2. Apply the proposed framework with the hope that a network acceptable to both the planners and decision makers would emerge.
3. This macronetwork is then coded into a detailed configuration as required by the implementation of travel demand forecasting models.
The application of the proposed framework will enable a planner to design and analyse networks in a more efficient way.

According to Gray and Hoel (1979), much of the improvement in urban mass transportation came about as a result of efforts by the National Government, urban interest groups including the transit industry. Emphasis was placed on the concept and approach to transit management that will permit the assets of a transit firm to be utilized more effectively. They observed: *Management is a critical but often overlooked element in a successful urban mass transportation service. The use of modern business management concepts and techniques makes sense in the process of improving transit service. The important thing is to focus on consumers and how best to serve them. Only in this way can public transportation meet the reality of today's competitive market of transit service, and the need to help improve life in U.S. urban areas.*

The Organisation for Economic Co-operation and Development (1980) looked at the various alternative measures that could be undertaken to change modal choice proportions. These included infrastructure measures geared to reducing travel times, improving the quality of public transport services through reserved lanes for buses and car-pools, preferential treatment at traffic lights and park-and-ride schemes. Another measure geared to improving public transport was through fare reductions, the adoption of monthly passes and tickets transferable between modes. Private automobile restraints included fuel pricing, physical restraint schemes and taxation measures. With regard to Urban Spatial Management, long term policies were directed towards land development patterns that were more supportive of public transport use.

According to Paquette et. al. (1982), a number of measures could be adopted to induce travellers to use existing vehicles at higher load factors. Among the measures that could be considered as effecting demand reduction include: ride sharing, improved bus services, transit marketing, park-and-ride systems, paratransit systems, road pricing and use of communications in lieu of transport.

A World Bank Policy Study (World Bank, 1986) on Urban Transport looked at improving efficiency by traffic management in addition to giving priority to public transport and other high occupancy vehicles. It was stated that since priority arrangement for public transport formed part of a more comprehensive traffic management scheme, other traffic were not necessarily worse off. Private drivers caught in congestion were tempted to use the special facilities provided for public transport. Hence the success of public transport priorities measures depended to a great extent on firm enforcement. According to the study: *Clearly defined subsidies may be justified where social and economic benefits have been accurately assessed and outweigh all the costs. But in general, it will be extremely difficult for cities to rely on subsidized public transport to meet future massive demands, which are growing much faster than budget revenues. As a result of this situation, much more emphasis is being placed on self - supporting services which are now flourishing in many cities in the Third World.*

Latchford (1986) looked at some of the traffic management techniques that could be applied to Greater Cairo in order to accommodate the rapidly rising day to day travel demands, with limited road space. He added that more efficient use should be made of existing transport facilities particularly roads and public transport. The use of high occupancy vehicles such as buses should be enhanced and the use of private cars should be discouraged. Special attention should be given to the transport requirements of lower income groups. Similar measures were cited for Bangkok in an attempt to reduce traffic demands to a manageable level. Latchford said that the approach of trying to reduce traffic demands could be achieved either by traffic restraints which actively deters motorists from using their vehicles or providing alternative travel methods that may encourage drivers to change mode of their own free will. The Thailand Government implemented their Traffic Management Project without major restraint policies but on the basis that in the future enhanced public transport, segregated and on-street, would lead to a lowering of private vehicle use.

Several committees recommended an increased share of mass transport and for supplementing the city bus services with a suitable tract based system. Chari and Ramamoorthy (1989) suggested an integrated approach for the planning and evaluation of mass transport system which included bus network and light rail technology (LRT) in urban areas. The approach involved a simplified procedure for determining mass transit demand, bus route network generation and evaluation, light or rapid transit corridor identification and its patronage determination in the combined presence of bus networks. Scheduling of mass transportation system based on marginal ridership concept was also suggested for a given fleet size. Software and interactive computer packages for demand estimation, route network generations and scheduling were developed with feedback mechanisms for the desired optimal solution in terms of performance indicators. It was envisaged that the proposed methodology for the overall planning and management of mass transport system through a systematic procedure will ensure a healthy interaction between track based and bus systems for efficient and conjunctive use. They believed that with efforts, the proposed methodology will prove to be of great help in improving the transit planning efficiency in many cities.

Roy (1989) looked at the development of an appropriate planning method for surface transit restructuring considering the impact of a new rapid rail system. He discussed the methods, techniques and process for the determination of minimum travel path and capacity. The methodology was developed as a four - phase process of analysis which commenced with a procedure for system choice followed by a procedure to simulate the manner in which mode(s) are selected for different transit links. The final phase involved a comprehensive assessment of the restructuring need. The methodology was also demonstrated for Calcutta as a case study and the surface transit restructuring needs were identified. The basic objective was to develop a rational and simple planning method and to demonstrate that it is feasible to apply it within a relatively short period of time, even for a large metropolitan city like Calcutta.

Kikushi and Rhee (1989) proposed a model for vehicle scheduling for a demand- responsive transportation system. The model was based on an operating environment consisting of many-to-many travel demands, multi vehicle, advanced reservation and time - window constraint for pickup and drop-off times. The method followed is essentially a two-step approach : building of an initial route, and insertion of additional trips into the initial route. With regard to inserting trips to the initial route, the model first checks feasibility of insertion for each trip and then identifies the maximum number of trips that can be inserted using a tree-structured search technique. The proposed method was evaluated for a set of specific examples by examining the sum of time differences between the original and actual pick-up and drop-off times, and the number of vehicles required.

According to ECMT (1990), traffic priorities for buses can reduce car use and therefore contribute to reducing environmental nuisance. The best known forms of traffic priorities for buses are bus lanes which assist in reducing transit times and increasing the reliability of service operation. These are widely used in many European cities. On wide highways, one lane can be set aside in each direction for the exclusive use of public transport vehicles. It was further stated: *Whilst rail and express bus services can compete with the car for substantial sections of journeys, they lack the door to door flexibility of the car. Therefore, if they are to be acceptable alternative over the entire journey, they need good access at either end. At the suburban end, park and ride will be especially important for those with cars available.* ECMT added that secure and convenient parking was needed close to public transport stations or stops for 'park and ride' to be effective. They also had to be served by frequent and fast services to the city/town centre. ECMT was of the opinion that the 'park and ride' strategy should reflect the availability of good quality public transport services.

Henry (1990) discussed the concept of integration pertaining to public transport. He explained that physical integration dealt with establishing transition permits between the Metro and the other transport modes : multimodal stations for interchange with trains, trolley buses, minibuses, or car parking places. He said that physical integration also meant redefining networks at the level of a conurbation by co-ordinating various urban and interurban guided transport systems mutually and with the road transport systems. Henry further emphasized the advantages of fare integration which was simply the facilitation of the use of two or several transport modes by the use of combined fare. He referred to the pricing policy and thus to the operation of the different modes. Finally, he spoke about institutional integration which referred to all the measures taken by the authorities and/or operators in view of co-ordinating the different subsystems and remedying negative aspects pertaining to public transport services. This also included co-ordination of administrative authorities performing the different functions of Trusteeship in urban transport.

Meakin (1990) recalled the commitment made by Hong Kong to a mass transit railway (MTR) in the early 1970 after forecasts showed that within twenty years the city's main corridors would be unable to accommodate the volume of traffic. After ten years of operation, public transport trips was increased by 50 %. He said that the MTR had met its primary objectives of enhancing mobility and meeting its financial targets and carried a quarter of public transport trips by the year 1989. Meaking also looked at the impact of MTR on other transport modes. As a result of the implementation of various integration proposals, MTR was fed by a network of 37 designated feeder routes which employed 290 buses which gave access to MTR from all major generators outside its corridor. Approximately 30 % of MTR passengers relied on a feeder bus to get to or from the railway. With regard to MTR patronage, in its first full year of operation, the system carried an average of 610 000 passengers per day. It was also revealed that the proximity to MTR had a significant effect on land values which resulted in the increase in the value of land in the industrial zone around Kwan Chung and Kwan Tong stations. Several major office blocks and a hotel was built within 400 m of the station in the Sang Wan area which would have been very difficult to market and would have commanded lower rents without access to MTR.

Skutil (1990) discussed the operations of high occupancy vehicles (HOVs) as a viable answer to the congestion and commuting problems caused by zoning. Skutil emphasised that HOV facilities for Africa was vital to the country's economy in general due to the escalation of road infrastructure, anticipated energy shortages and environmental shortages. The objectives of HOV lane operation as well as the categories and suitability of HOV priority treatments are well presented in his paper.

According to Tobia (1990), the arrival of the Metro produced dramatic changes in the quality of urban public transport services in Caracas. The users had eventually discovered the meaning of good, comfortable and reliable public transport service. According to a recent survey amongst the commuters, it was found the 49 % of the users were either professionals, technicians or white collar workers. It was also revealed that 38 % of the travellers transferred from the metro to other vehicular modes with the metrobus system being the most significant mode of metrofeeding. The metrobus system used an integrated ticket that allowed one trip on the bus plus one trip on the metro or vice versa. The portion of the bus fare was constant for all routes and the difference in ticket prices arose solely for the zonal portion of the metro trip. Discounts were also allowed for students using special multitrip ticket. Access to, and exit from the passengers "paid" area was gained by inserting magnetically encoded tickets in automatic turnstiles. Tobia admitted that the impact of the metro on the city had taken many positive forms.

The rail system represents a valuable investment in a high capacity mode which is not influenced by traffic congestion. Effective marketing strategy is of importance to encourage rail patronage. Welmsley and Perrett (1992) looked at the effects of rapid transit on public transport and urban development in Great Britain, France, USA and Canada. The recent revival of interest in Britain in rapid transit systems has led to the study of fourteen such systems in France, USA and Canada. The effects of rapid transit on patronage in France revealed that ex-car users accounted for approximately 12% of the rapid transit passengers. It was found in most of the areas that rapid transit is attractive to car travellers, whether by virtue of its speed advantage over buses, more comfortable journey, no traffic congestion or better image.

Macpherson (1993) looked at various methods of implementing traffic management. He said that one of the most direct method of limiting travel demand was through the pricing system whereby motorists were charged directly for use of the road. With the improvement of rail technology and the extension of the network, and consequent reduction in journey times, the commuter zone around London steadily increased. Park and ride, which widened the range of opportunity of commuters, was extended through ticketing systems that made efficient use of spare capacity by offering substantial discounts during off-peak travel. Macpherson also emphasised the increase in the degree of congestion in city centres with the increase in car ownership. He said that with major road construction in urban centres been ruled out by economic and political considerations, planners have again turned to park and ride as a potential solution, possibly the only solution. Macpheson added that the Government's view was that park and ride could make a positive contribution to alleviating congestion and improving the environment. It was estimated that about 36 park and ride schemes were introduced in Britain during the period 1981-1990, of which 29 came in the period 1987-1990.

The following comment was clearly highlighted in The Interim Transport Plan for the Durban Metropolitan Transport Area (1990) : *The most efficient mover of large numbers of people is generally the railway system, which must be supported to the hilt, where feasible, and justified, in its operation and expansion.*

Tiwari et. al. (1995) presented a procedure for operational analysis of Bus-MRT integration, a system in which buses and the mass rapid transit (MRT) system weld their services to provide a single network for commuters. They looked at the prevailing conditions in Delhi for providing public transport to commuters which was found to be deteriorating rapidly. They considered MRT as a major step to achieve a goal of non-congestion, efficient and speeding service but obviously relied on the buses to play a part as feeder services. The parameters and factors involved in Bus-MRT integration were presented as well as the various aspects for the development of a simulation model for the operational analysis of Bus-MRT integration was discussed and presented in their paper. The expected benefits of this approach included the reduction in the use of private vehicles, reduction in travel time, reduction in fuel consumption, reduction in accidents, reduction in air and noise pollution and increase in comfort and safety.

Johnston et. al. (1995) reviewed a variety of existing and proposed methods for allocating existing highway capacity to lessen congestion and congestion costs. The objectives of highway capacity allocation included: effectiveness at reducing congestion, economic efficiency, income distribution effects and flexibility of access for urgent travel needs. Several roadway capacity-allocations approaches were explored and the measure's potential for effectiveness in reducing congestion were discussed. These approaches included the Laissez-Faire allocation, allocation by vehicle passenger load, ramp metering, road parking and area pricing and rationing. Although it was stated that most of these measures are impractical today and many will be impractical in the near future, with the expansion of roadway capacity becoming increasingly expensive and controversial, roadway capacity-allocation measures will become relatively more desirable and will attract more political and professional attention.

Martinelli (1996) looked at the service characteristics of busways and cited operating speed as probably the most significant factor in travel time. Busways that operate separate from general traffic can achieve line-haul speeds of 80km/h, given sufficient acceleration distances. A further speed advantage of busways was that vehicles were able to pass each other in station areas under skip-stop operation and in case of vehicle breakdowns, the ability to pass also contributes to system reliability. Of serious concern to commuters was accident prevention and safety. Experience with exclusive busway systems have shown extremely low accident rates. In general the accessibility of busways was quite high because the vehicles can operate on residential streets as well as the line haul. Furthermore it provided the opportunity for a one seat ride from outlying areas to the city centre. Also, busways were especially cost effective for regions that were already operating a fleet of buses.

Heierli (1996) discussed the recent transport developments in Zurich and the approval of a grant for improving the trainway network. It was recognised that, if urban public transport was to be attractive, it had to be punctual, offer a sufficient number of seats and provide a frequent service. With regard to punctuality, every intersection was optimized with the objective of a "zero waiting time" for trains and buses. Public transport vehicles were equipped with special devices making it possible for the traffic computer to select the best possible combination of lights. Whenever space was available, trains were given their own reserved track protected by physical means. The standard train vehicle currently in use was a very comfortable and aesthetic one capable of accommodating up to 100 seated passengers. They operated at a basic fixed headway of 7 - 8 minutes throughout most of the day, which was even reduced to 5 minutes on heavily used routes during peak periods. Zurich also saw the operation of the S-Bahn, a rapid transit network with fast trains to the Zurich suburbs. Zurich's central station was transformed into a modern multi-level interchange and became an attractive centre of Public transport. the daily pedestrian movements were increased to 300 000 with the potential for further development.

Wells and Hutchinson (1996) studied the impacts of commuter-rail services in the Toronto region. The demand for rail services in the Toronto region increased at an annual compound growth rate of 11.4% between its inception in 1967 and 1989. The annual growth in commuter-rail demand was lower between 1990 and 1994 but this was mainly due to the strong suburbanization of office-based employment during the late 1980s, early 1990s and the lower rate of economic development. There was a decrease in car ownership with good access to rail services for the small and medium household sizes. However, urban economic theory suggest that commuter rail services are most likely to cater for larger households with the primary worker employed in the CBD, who is prepared to trade off increased commuting distance against increased land consumption for residential use. The demand for rail was reinforced by the provision of excellent park-and-ride and kiss-and-ride facilities at the suburban end with the systematic integration of major CBD office complexes with the comprehensive underground pedestrian network connecting these complexes to the station.

When Kanthilal (1996) asked respondents in the Overport area to suggest solutions to improve the minibus service, most of them said that positive measures needed to be adopted. *Eighty seven percent felt that enforcing strict penalties on operators guilty of speeding and reckless driving could act as a deterrent. Also, many felt that on-the-spot fines require immediate payment, would be more effective. This they felt will resolve the problem of having to track the operators, a serious problem currently experienced by the City Traffic Department. Eighty percent of the respondents expressed the need to suspend those operators guilty of delivering poor disciplinary measures as another way to improve the mini bus services.* Some of the recommendations given by

Kanthilal that could assist in overcoming and/or alleviating the identified problems associated with the Overport mini bus included a more prescriptive method with regard to issuing of permits, proper record keeping, proper quality control measures, development of business and management skills, efficient rank operation, improvement of driving skills and driver behaviours. The planning and provision of adequate infrastructure was also highlighted.

2.3 Conclusion

Several researchers have addressed the problems associated with the decline in public transport and the tremendous demand placed on many cities in providing for the increase in private vehicle usage. Many authors also highlighted the urgent need to reduce congestion on our roads. The review of literature brings out the fact that though there has been some important work done by some individual researchers regarding improving public transport, not much has been done in the South African context with regard to coordination and integration of public transport modes. The Government of South Africa fully supports modal integration has made it clear that independent planning by modal operators should be discouraged since the passenger transport plan should be comprehensive and cover all modes. The present study aims at evolving a methodology in this regard.

CHAPTER 3

ASSESSMENT OF THE CURRENT TRANSPORT SITUATION

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3.1 Introduction

It has been mentioned in Chapter 1 that Chatsworth, a suburban area of Durban has been considered for detailed investigation in this study. As a first step, a study was undertaken to assess the present transport situation in the area. This included traffic and accident studies on the Higginson Highway (M1) and all major intersections to the Highway, infrastructure requirements pertaining to bus, minibus taxis and rail with emphasis on rail patronage and associated/available facilities. A close study was also carried out on the utilization of parking bays at all five rail stations in Chatsworth.

The assessment on the current transport situation was mainly conducted during the period between June 1996 and November 1996. However, some of the more recent developments and "incidents" that occurred after the investigation were also recorded. The assessment included on-site investigations in addition to obtaining data from Metro Rail (Durban),Traffic and Transportation Department (Durban Corporation), Chatsworth Minibus Association, Chatsworth Bus Operators Association as well as from the commuters in the area. It was also necessary to look at the past or history of the transport system in order to identify possible reasons for the decline in public transport especially the metro rail system.

3.2 Road Transport

After much investigations and proposals outlining the need for a second access road to cater for commuter traffic between Chatsworth and the city centre, some 15 years have passed and the Higginson Highway still provides the only major access road for traffic moving directly into and out of Chatsworth. Over the last two decades , road intersections to the highway were improved with certain sections of the highway being upgraded to dual and 3-lane carriageways. However, with the steady increase in car ownership and usage, the effects or benefits of these improvements were soon exhausted. Spare capacity was very quickly used up during the morning and afternoon peaks resulting in forced flow driving conditions (Figure 3.1) with accidents and pollution an endemic social problem with serious economic consequences.

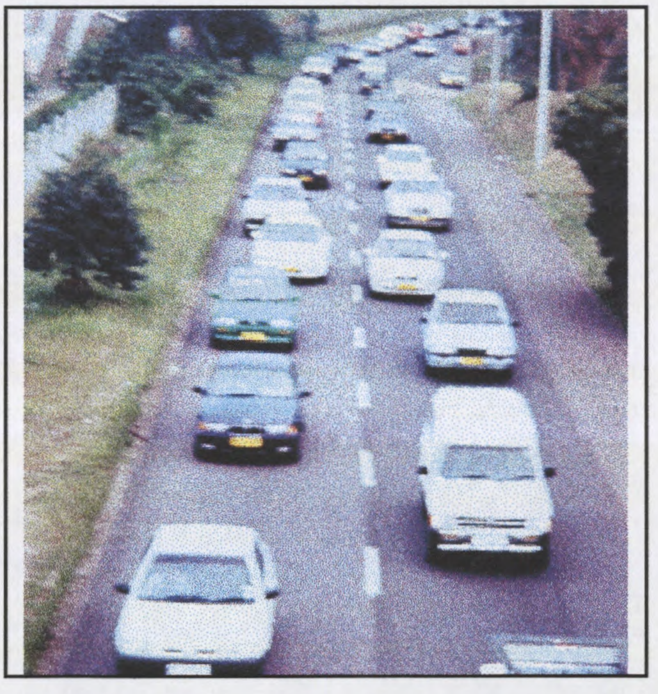


Figure 3.1: Forced flow condition on Higginson Highway

Volumes in excess of 4800 vehicles per hour have been recorded during the am peak. Table 3.1 reflects the am peak hour volume on Higginson Highway (M1) over the years. A similar trend was reflected during the pm peak hour.

TABLE 3.1: AM PEAK HOUR VOLUME ON HIGGINSON HIGHWAY

YEAR	1988	1989	1990	1991	1992	1994	1996
Peak Hr Volume	2926	3612	3749	3981	3771	4209	4863

One of the very few "escape" routes from this area to the Durban CBD is Astral Drive (M22), a 2-lane 2-way road. Traffic departing as well as approaching Higginson Highway on the M22 has shown significant increase over the years with the two way total (am peak hour) in 1992 almost twice the volume recorded in 1985. Table 3.2 indicates the two way total volume (am/pm peak hour) on the M22 over the years.

TABLE 3.2 : ALL VEHICLE VOLUME ON ASTRAL DRIVE (2 WAY TOTAL)

YEAR	1985	1986	1987	1988	1990	1991	1992
AM PEAK HR	872	1201	1231	1240	1365	1453	1594
PM PEAK HR	1208	1210	1223	1245	1524	1617	1685

All major intersections to Higginson Highway also revealed a steady increase in vehicle volume. Peak hour factors as high as 0.97 has been recorded at some of the intersections. Table 3.3 reflects the total "all vehicle" volume at some of the main intersections over the years. The survey was carried out over a time period of 11,5 hours.

TABLE 3.3 : TOTAL INTERSECTION "ALL VEHICLE" VOLUMES

INTERSECTION/YEAR	1988	1989	1990	1991
HIGGINSON/ASTRAL	10450	******	10816	12973
HIGGINSON/HAVENSIDE	28405	27441	28512	31168
HIGGINSON/MOBENI HTS	29246	30195	30805	35524
HIGGINSON/PELICAN	9369	9707	11109	12141

****** indicates that no survey was conducted.

The survey area falls under the South Central Sub-Structure in the Durban Metropolitan Area. This sub-structure recorded the highest number of accidents from all the six sub-structures. 41% of the total reported accidents and 44% of the total reported pedestrian accidents occurred in this sub-structure. From the thirteen areas listed in this sub-structure, Chatsworth recorded the third highest number of accidents - a total of 3191 for the year 1995. Table 3.4 reflects the total number of accidents in 1995 for the different areas listed under the South Central Sub-Structure.

If one focussed on the Higginson Highway (M1), more than 35% of the accidents occurred during the am and pm 2 hour peak. More than 71% of all accidents on the M1 involved motor cars. Over a period of just three years (1993 to 1995), this highway recorded a 28% increase in the number of accidents. All major intersections to the M1 also reflected a marked increase in the number of accidents over the last few years.

TABLE 3.4 : NUMBER OF ACCIDENTS BY INJURY CLASSIFICATION

Area	Fatal	Serious	Slight	No injury	Total
Central-South	29	124	640	3862	2121
Industrial	51	109	523	3869	4552
Chatsworth	**26**	**84**	**413**	**2668**	**3191**
Umlazi	74	203	412	1531	2220
Berea South	10	50	236	1825	2121
Old line Suburbs	6	30	139	855	1030
Harbour	7	28	104	861	1000
Cato Manor	14	40	171	676	901
Merebank	2	12	119	508	641
Bluff	11	12	90	490	603
Montlands	1	4	43	217	265
Lamontville	6	23	50	109	188
Yellow Wood Park	0	0	3	32	35
Totals	237	719	2943	17503	21402

If one looked at all the intersections in the South Central Sub-Structure with respect to the highest number of accidents, the Higginson Highway/Outer Ring Road and the Higginson Highway/Havenside Drive intersections featured very high (2nd and 5th respectively) amongst the 30 "worst" intersections in this sub-structure. Table 3.5 reflects just 20 of the "critical" intersections in this sub-structure.

TABLE 3.5 : INTERSECTIONS HAVING THE HIGHEST NUMBER OF ACCIDENTS IN THE SOUTH CENTRAL SUB-STRUCTURE

Intersection	Total accidents
Edwin Swales Dr. - South Coast Rd.	191
Higginson Highway - Outer Ring Rd.	**179**
Wakesleigh Rd. - Edwin Swales Dr./Bellair Rd.	125
Canongate Rd. - Warwick Avenue/Leopold Street	116
Mangosuthu Highway (M30) - Road to V Section	113
Higginson Highway - Havenside Drive	**95**
West Street - Field Street	81
Grey Street - West Street/Broad Street	81
South Coast Rd. - Blamey Rd.	78
Grey Street - Leopold Street	77
Grey Street - Commercial Rd./Eilat Viaduct Off Ramp	77
Aliwal Street - Victoria Embankment	66
Alexander Street - Russel Street/West Street	64
Gardiner Street - Smith Street	64
Victoria Embankment - Broad Street	62

If one focuses on the Higginson Highway/Havenside Drive intersection, it can be seen that the number of collisions over the years have increased. Table 3.6 highlights the steady increase in accidents at this intersection over the years.

TABLE 3.6 : TOTAL NUMBER OF COLLISIONS AT THE HIGGINSON HIGHWAY - HAVENSIDE DRIVE INTERSECTION OVER THE YEARS

Year	1992	1993	1994	1995
Total number of collisions	52	61	75	95

The above table indicates an increase of 83% in the accident rate at this intersection over the four year period stated. The Higginson Highway/Outer Ring Road intersection also showed an increase in the number of accidents over the years with the 1995 figures reaching 179.

Statistics revealed that the majority of the accidents was due to rear end collisions involving mainly motor cars. This could also be attributed to the forced and unstable flow conditions experienced on this highway.

3.2.1 Bus Transport

Bus transport remained an indispensable element of the passenger transport system by providing a service to approximately 66% of public transport commuters in this area. This mode of transport was initially offered to the residents just after the development of the area in the early 1960s. Many of the operators, through severe hardship, purchased buses costing millions of rand which served as the only means of transport to the community at that stage. When rail transport was introduced to the area in 1971, the Government, at that time, made every effort to rid the area of buses. However, the Chatsworth bus operators won this legal battle which reached the level of supreme court and continued to survive thus improving living standards and mobility through service provision. This was a major setback to the bus industry and to their commuters since the number of buses serving the area was reduced by over 30%. This was due to some of the bus operators losing their permits after failing to appeal against the demand for exclusive right of way by the railways.

The bus and taxi associations, with time, gradually began to accept one another until recently (November/December 1995) when the minibus taxis were granted permission to operate on the Durban CBD route. This led to numerous conflicts, intimidation and fierce competition between the two modes.
At present, the greater portion of the public transport commuters are transported by bus which very often results in overcrowding during the peak periods. Although the service is non-subsidised, similar to the minibus operation, the average daily fare to the Durban CBD was slightly cheaper than the combi-taxi or rail. However the rail fare was much lower when purchasing a weekly or monthly ticket. The Chatsworth Bus Operators Association is the umbrella body for the following associations:

1. Unit 1 (Havenside) Operators
2. Unit 2 (Bayview) Operators
3. Unit 3 (Westcliff) Operators
4. Crofdene Bus Owners
5. Unit 6/7 and Inner Circle Bus Operators
6. Unit 10/Umhlatuzana Bus Operators

An on site investigation revealed that the bus infrastructure requirements were hopelessly inadequate. Bus ranks were virtually non-existent with just the Bayview area having a small strip of vacant land. Bus operators were forced to park on the side walks/pavements (Figure 3.2) and at times reduced the effective width of the road. This created medial traffic friction which obviously had serious impacts on the capacity of the roadway in addition to being a hazard to other motorists.

Figure 3.2 : Pavement used as a bus rank

Bus shelters and bus lay-byes were limited with no ablution facilities for commuters or drivers. Bus drivers/conductors/rank marshals, etc. were embarrassed of the fact that they had to frequently approach private residents when requiring the use of toilet facilities or even for drinking water. Some of the executive members of the Chatsworth Bus Operators Association commented that it was common to see a bus bay provided on one side of the road only although sufficient space was available for a bay on the opposite side. This resulted in the operators stopping on the roadway which led to traffic congestion and driver frustration. Many operators felt that too much flexibility was given to the taxi association whilst their permits were specific with regard to the route to be traversed and the time table to be operated. They further commented that the city police/SAPS favoured minibus taxis and constantly harassed the bus drivers. They also claimed that some members of the SAPS owned a portion of the taxi fleet. However it was interesting to note that the opposite view was held by minibus taxi operators. Lack of subsidy, increased cost of fuel and the pressures to keep fares as low as possible had resulted in over crowding, long journey times (waiting for passengers) and also had a serious impact on the reliability of the system. It was also highlighted that over the last twenty years, no additional permits were granted to bus operators. One of the rank managers interviewed confirmed that, during his twelve years with the Association, there was a steady decline in bus patronage, either to minibus taxis or private vehicles.

It was also observed that some drivers had the tendency of stopping on the traffic lane in order to initiate a conversation with a colleague (bus driver/operator) travelling in the opposite direction. This, off course, was at the expense of the passengers and other motorists who were forced to have their journey times deliberately increased. This could also be seen as a "strategic move" on the part of the driver so as to "buy" time in order to accumulate more passengers on route. Similar scenes were observed between minibuses as well as between bus and minibus with the latter very often deviating from the usual friendly chat.

Some of the commuters interviewed expressed concern regarding the increase in "pick pockets" that thrived on buses. Many of them felt that no proper planning was conducted in co-ordinating the bus and taxi system in order to benefit the community. They also felt that more buses were needed during the peak periods in order to overcome crowding and therefore increase the level of comfort.
Chatsworth was one of the areas that suffered the most from the recent police sick leave action, which members of the SAPS embarked on to voice their dissatisfaction with the Government's 7.5% salary increase. The Bayview police station, which normally has a team of 78, had to make do with only few members. It was understood that crime in the area had increased as a result of minimal police presence which certainly had an impact on the safety of public transport. The mobility which this mode of transport provides cannot be over emphasised. An efficient and thriving bus industry has the potential to make a significant contribution to future economic growth in addition to curbing the distinct shift to private transport.

3.2.2 Minibus Taxi

The minibus taxi has been hailed by many as a major break through by black entrepreneurs into the country's formal economic system. They contribute substantially to meeting the daily commuters needs of residents in the metropolitan area as well as those travelling to and from the area. According to latest figures from the National Taxi Task Team, set up early last year, minibus taxis provide transport to about 2.2 million South Africans, about half the country's commuter service. The minibus taxis, sometimes referred to as "combi" taxis have become popular due to its "door-to-door" service thus surpassing other modes of public transport with regard to convenience and accessibility. The minibus taxi industry operates without subsidy, where the operational services are unmetered and fares work on a cash basis only. The recent survey in the area revealed that approximately 25% of public transport commuters used this mode of travel. They operate on the same route as the buses with some minor deviations.

While the minibus industry can be seen as a solution to many of South Africa's transport problems, it has also given rise to several problems. One of the problems facing the minibus industry, in general, was the high accident rate. The main cause of accidents have been attributed to gross overloading, unlicensed drivers, unroadworthy vehicles, reckless and high speed driving.

According to one of the officials of the Chatsworth Minibus Association, the taxi service in this area (innercircle route) commenced operation in 1976 and only recently (December 1995) was granted permission to operate to the Durban CBD. No fixed time table was adopted but some process of "rotational shift" was applied over a period ranging from 5am to 8pm. Approximately 200 taxis have been allocated the inner circle route (in Chatsworth) while approximately 50 taxis operate on the Durban CBD route. Fares on the inner circle route ranged from R1-00 to R1-50 while the average cost to the Durban CBD was approximately R3-00. The management team claimed that the Minibus Association had "come a long way from the apartheid days" and that the Association was not taken seriously until recently. With assistance from the Durban City Police, SAP (Chatsworth) and members of the Local Roads Transport Board (LRTB), the Chatsworth Minibus Liaison Forum was established. It was pleasing to note the Association had close affiliation with Child Welfare and the Bayview and Chatsworth Policing Forum.

However all was not rosy as indicated by some of the operators/owners. It was highlighted that many of the permits were issued without consultation with the Association which resulted in flooding of the market and a shrinkage in business for the existing operators. However some of them did indicate that there were times when the buses and taxis were unable to cope with the demand. It was also alleged that drivers with permits from other areas (eg. Phoenix,Umlazi) were operating in the Chatsworth area resulting in on-going tension and feuds. Strong resistance and pressure was applied by the Chatsworth Bus Operators Association to the minibus taxi operating initially on the inner circle route and more recently on the Durban CBD route. Many taxi operators claimed that their vehicles were prevented access by the bus operators. Allegations that some taxi drivers took drugs and alcohol while operating their business were made by other taxi drivers who further emphasised the lack of regulation and control in the minibus taxi industry. This obviously had a direct impact on the patronage resulting in many commuters switching to private transport as highlighted by the home interview survey. It was also revealed that many operators/drivers were "encouraged" to overload their minibuses since their salaries were based on a commission system. "Chasing for commuters" also contributed to unsafe driving and accidents. Although most of the vehicles were designed for 16 passengers, many operators admitted carrying more than the legally recommended number of passengers. Some drivers complained of poor conditions of service while taxi owners complained that some of their drivers were supplementing their wages through pilfering of takings.

It was reported recently in several newspapers that the taxi industry in South Africa had become a free-wheeling "monster" where money and power were the bottom line and men with guns ruled the highways. Thousands of commuters, taxi owners and drivers have died in bloody power struggles over ranks and routes. The issue of radius and casual trips (on LRTB permits) made the work of enforcement departments very difficult in prosecuting the offenders. This led to numerous conflicts, assaults and the so-called "taxi wars" between drivers competing for business. Intimidation by gangsters using the taxi service compounded the problem of decreasing public transport patronage. Hijacking and theft of minibuses had gone completely out of hand and caused the insurance on minibuses to increase. This certainly deterred minibus owners from buying new vehicles to upgrade their fleet in order to enhance reliability and safety. According to one of the rank managers, untrained drivers were also adding to the safety aspect by simply taking the law into their own hands and therefore went beyond the control and policing of the industry. A few cases of bribery and corruption were also highlighted by some of the drivers. Permits were handed out to other prospective operators for huge sums of money. Some users complained that there was no uniformity in the charging of fares amongst different operators.

It was also observed that some drivers did not make use of the few lay-byes that were provided. They preferred stopping on the main traffic lane to pick-up or drop off passengers thus causing delays and frustration to other motorists. Whether this selfish action on the part of the driver was simply due to force of habit because of limited lay-byes of whether this was sheer laziness on their part, the need for driver education and associated training programmes were inevitable. In general, it appeared as if most of the drivers/owners displayed very poor business and communication skills.

Figure 3.3 : Reduction in the effective width of the road

Infrastructure was inadequate with no formal ranks provided. The car park at the Havenside rail station was used as a taxi rank while another informal rank was located at the Chatsworth Centre Shopping Complex. Lay-byes were not provided at strategic points resulting in minibuses and buses stopping on the carriageway in order to pick-up of drop-off passengers. The problem was further compounded when both public transport operators stopped on either side of the road which seriously affected the effective width of the road, thus causing medial traffic friction, driver frustration, and a further reduction in the capacity of the roadway (Figure 3.3). In addition, the lack of sufficient ablution facilities, shelters and associate infrastructure for commuters, drivers and rank marshals have been identified as a major problem.

Generally, the provision of rank space was on an adhoc basis and "created" at areas of potential demand. No prior planning was carried out in order to integrate the system with other modes and to cater for future demands. Many commuters cited the level of comfort and service provided as inadequate. Users generally complained of overcrowding and also experienced problems getting on and off the taxis, especially with parcels. One of the pensioners interviewed related her unfortunate experience while alighting from the taxi. The driver was so hasty to pick up other passengers that he virtually drove off, dragging this poor senior citizen a good few metres. Belligerent drivers, loud music, lack of time tables, off-peak waiting times and inadequate facilities were some of the complaints from the commuters. Drivers sometimes became aggressive and spiteful when reprimanded for reckless and dangerous driving. It is alleged that some drivers are rude and inconsiderate, while compelling passengers to accept uncomfortable seating (overloading in order to make a higher profit). Generally, there seemed to be a lack of a formal structure to handle complaints and to listen to the needs of both passengers and drivers.

The minibus taxi industry provides a valuable service to a lot of commuters and whilst the main objective of the operators is to make the most profit, the promotion of safe, secure, reliable and sustainable passenger transport must not be overlooked. Every effort is required to make this industry more efficient to the commuter.

3.3 Rail Transport

3.3.1 Service and Patronage

The Chatsworth spur line (Figure 3.4), a track distance of approximately 26 kilometres from Durban Station, consists of five stations: Havenside, Bayview, Westcliff, Chatsglen and Crossmoor. Figure 3.5 reflects Havenside Station which is the closest of the five stations in the area to Durban Station. Bayview Station (Figure 3.6) is the only station that has the ticket offices centrally situated. Figure 3.7 shows Westcliff station which is the *central* station in the survey area and, like the three other stations, has the station building situated on one side of Higginson Highway. Figure 3.8 reflects Chatsglen Station which is closer to Arena Park and adjoining Westcliff. The station car park is not shown on the figure since it is not located at close proximity to the station building. The Crossmoor Station (Figure 3.9) is the furthest station in the study area from Durban Station. The car park provided at this station is much larger than those provided at the other four stations in the area. The five train-sets operating on this service is composed of 3 motor coaches and 6 plain trailers giving a total of 9 coaches. The service frequency during the three hour am peak (05h00-08h00) ranges between 15 to 30 minutes. The service frequency during the off peak is very irregular (up to 4 hours). The patronage on this service peaked approximately 15 years ago and has been declining steadily ever since.

The number of passengers entering two of the rail stations, namely Bayview and Westcliff, during the am peak hour are reflected in Table 3.7 and Table 3.8 respectively. The drop in patronage since 1983 was as high as 80 percent.

TABLE 3.7: PEAK HOUR PASSENGER VOLUME FOR BAYVIEW STATION BETWEEN 1983 AND 1995

Year	1983	1984	1986	1987	1988	1989	1990	1992	1994	1995
No.	1129	788	585	567	436	426	296	250	220	186

TABLE 3.8 : PEAK HOUR PASSENGER VOLUME FOR WESTCLIFF STATION BETWEEN 1983 AND 1995

Year	1983	1984	1986	1989	1990	1992	1994	1995
No.	1551	1110	700	621	409	425	351	331

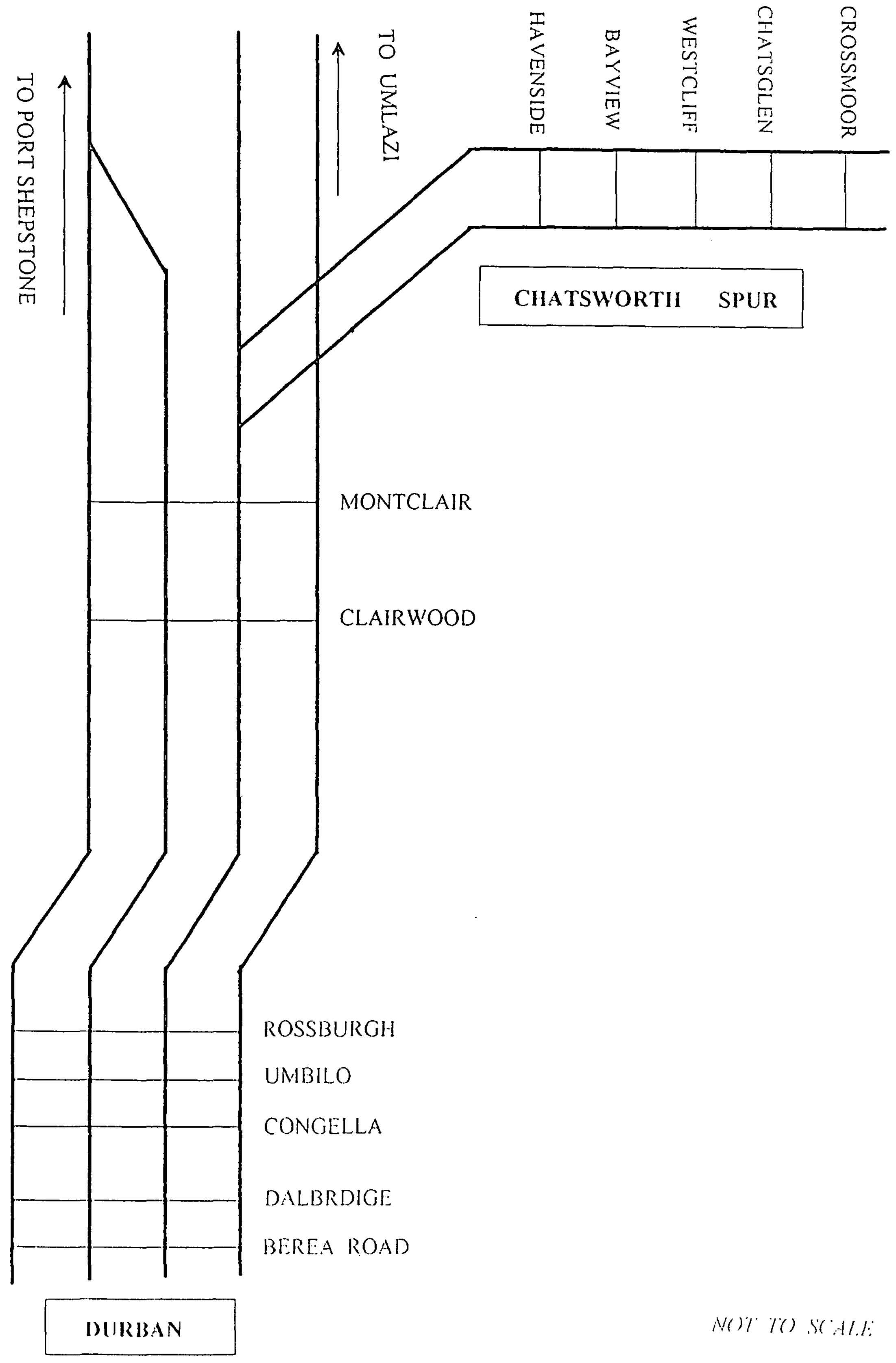


FIGURE 3.4 : Location of Chatsworth Spur Line

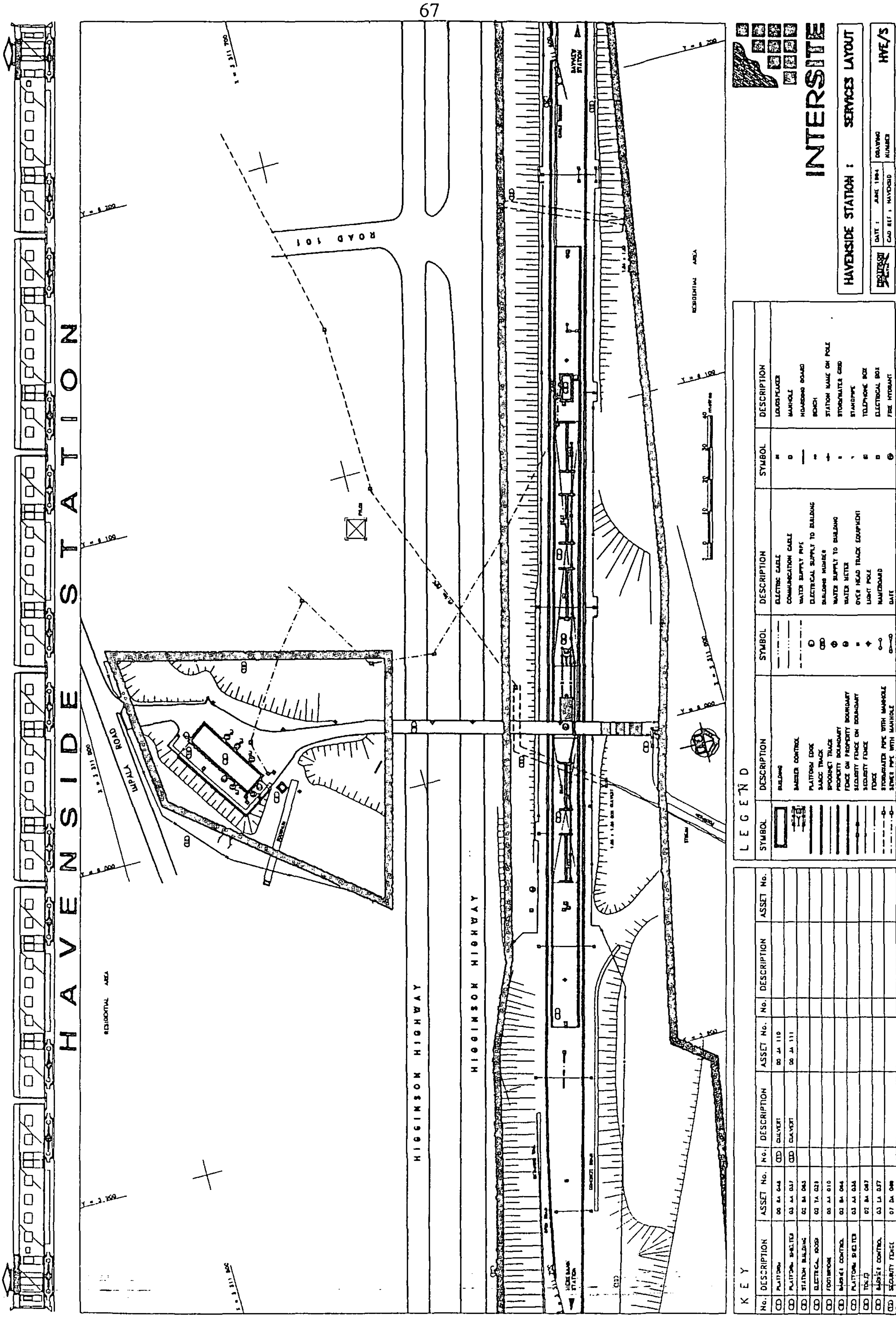


FIGURE 3.5 : Havenside Station

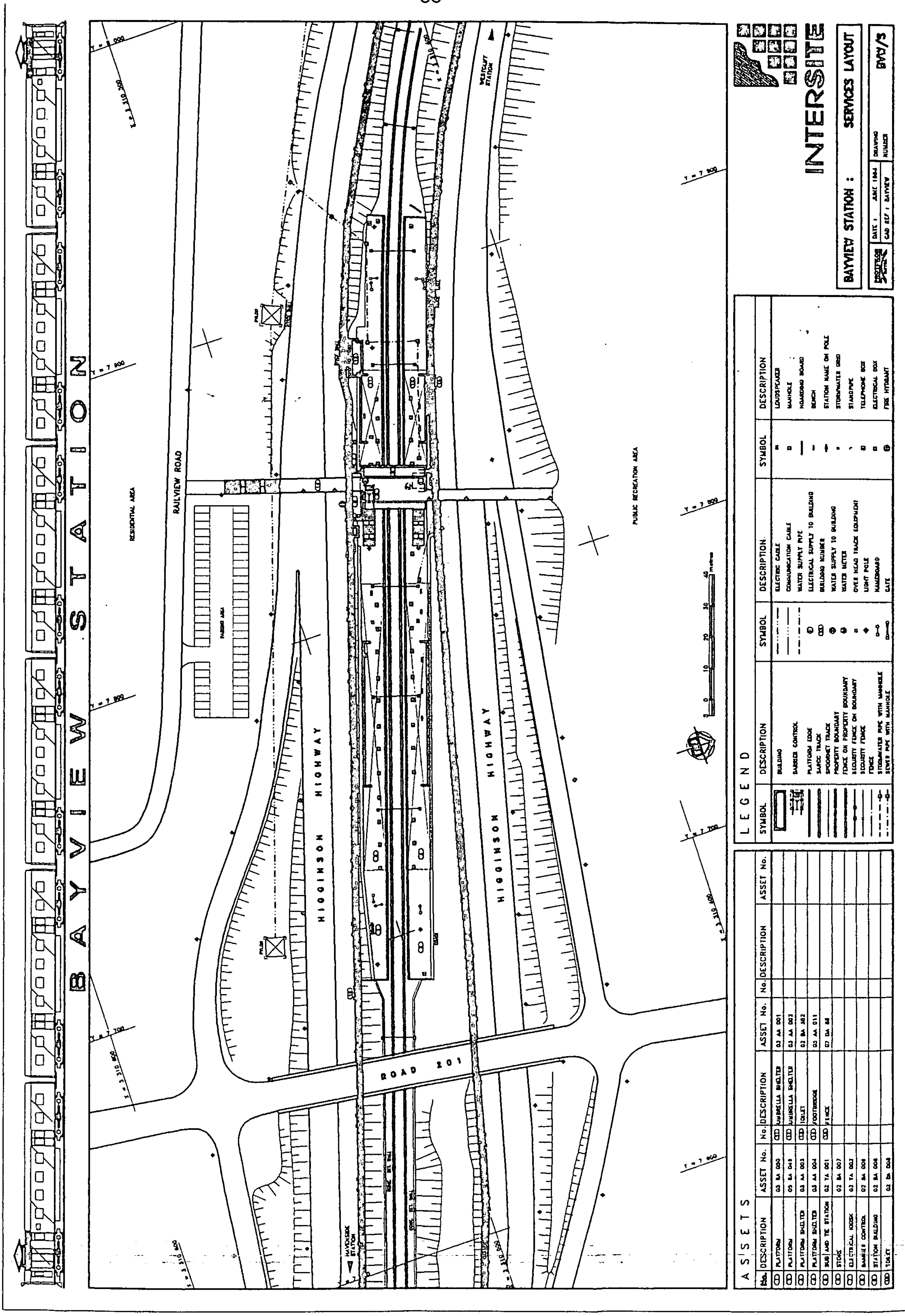
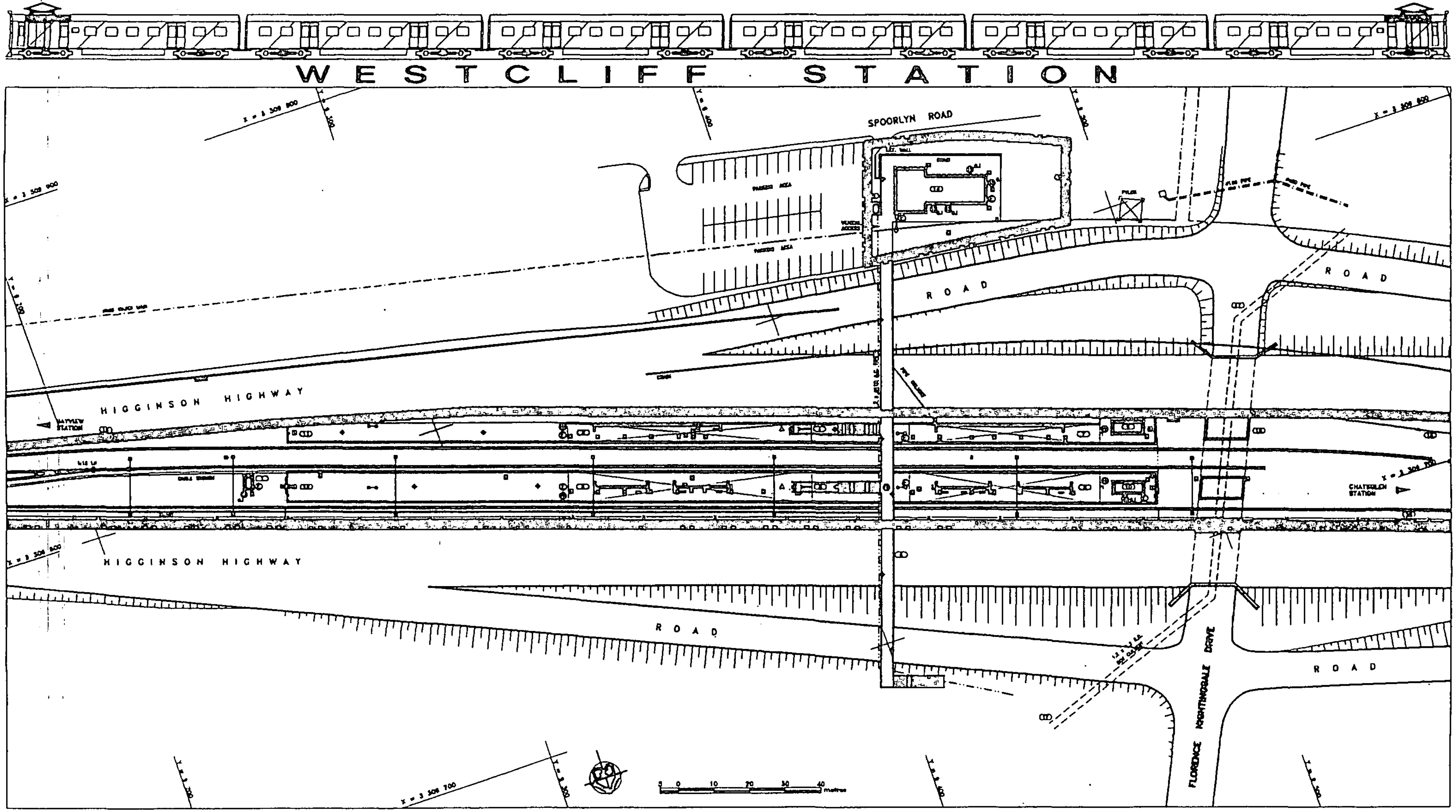


FIGURE 3.6 : Bayview Station



KEY

No.	DESCRIPTION	ASSET No.	No.	DESCRIPTION	ASSET No.	No.	DESCRIPTION	ASSET No.
[illegible]	TOILET	02 AA 272	[illegible]	PLATFORM	05 BA 031			
[illegible]	PLATFORM SHELTER	03 AA 042	[illegible]	PLATFORM	05 BA 002			
[illegible]	PLATFORM SHELTER	03 AA 041	[illegible]	BUS AND TIE STATION	02 YA 177			
[illegible]	BARRIER CONTROL	02 BA 341	[illegible]	STATION BUILDING	02 BA 337			
[illegible]	BARRIER CONTROL	02 BA 340	[illegible]	SECURITY FENCE	07 DA 004			
[illegible]	FOOTBRIDGE	05 AA 012	[illegible]	BRIDGE	06 DA 014			
[illegible]	PLATFORM SHELTER	03 AA 040	[illegible]	CULVERT	05 JA 120			
[illegible]	PLATFORM SHELTER	03 AA 038						
[illegible]	TOILET	02 BA 338						
[illegible]	TOILET	02 BA 342						

LEGEND

SYMBOL	DESCRIPTION	SYMBOL	DESCRIPTION	SYMBOL	DESCRIPTION
	BUILDING		ELECTRIC CABLE		LOUDSPEAKER
	BARRIER CONTROL		COMMUNICATION CABLE		MANHOLE
	PLATFORM EDGE		WATER SUPPLY PIPE		HOARDING BOARD
	SARCC TRACK		ELECTRICAL SUPPLY TO BUILDING		BENCH
	SPOORNET TRACK		BUILDING NUMBER		STATION NAME ON POLE
	PROPERTY BOUNDARY		WATER SUPPLY TO BUILDING		STORMWATER GRID
	FENCE ON PROPERTY BOUNDARY		WATER METER		STANDPIPE
	SECURITY FENCE ON BOUNDARY		OVER HEAD TRACK EQUIPMENT		TELEPHONE BOX
	SECURITY FENCE		LIGHT POLE		ELECTRICAL BOX
	FENCE		NAMEBOARD		FIRE HYDRANT
	STORMWATER PIPE WITH MANHOLE		GATE		
	SEWER PIPE WITH MANHOLE				

INTERSITE

WESTCLIFF STATION : SERVICES LAYOUT

DATE : JUNE 1994
CAD REF : WESTCLIFF
DRAWING NUMBER WCF/S

FIGURE 3.7 : Westcliff Station

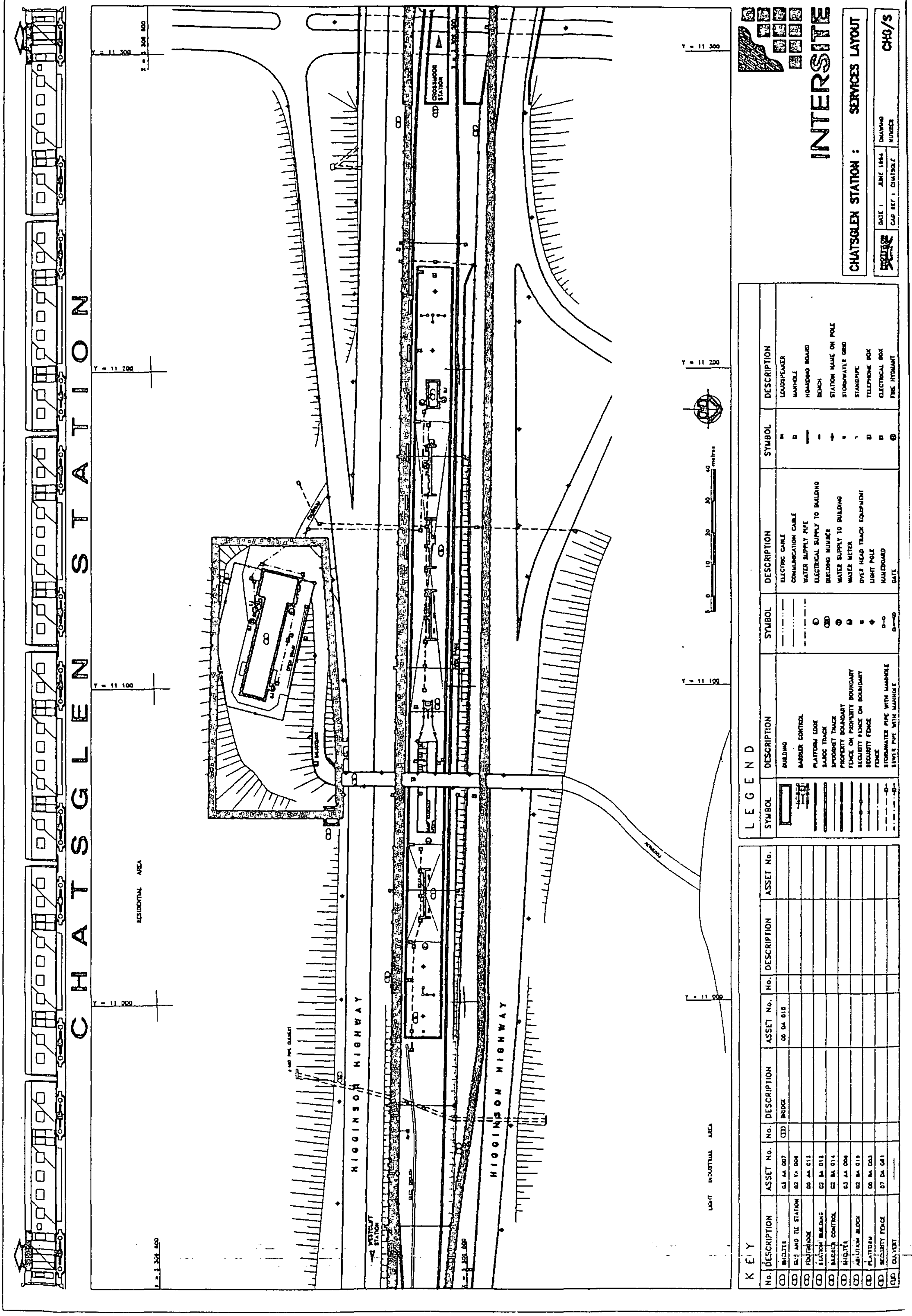


FIGURE 3.8 : Chatsglen Station

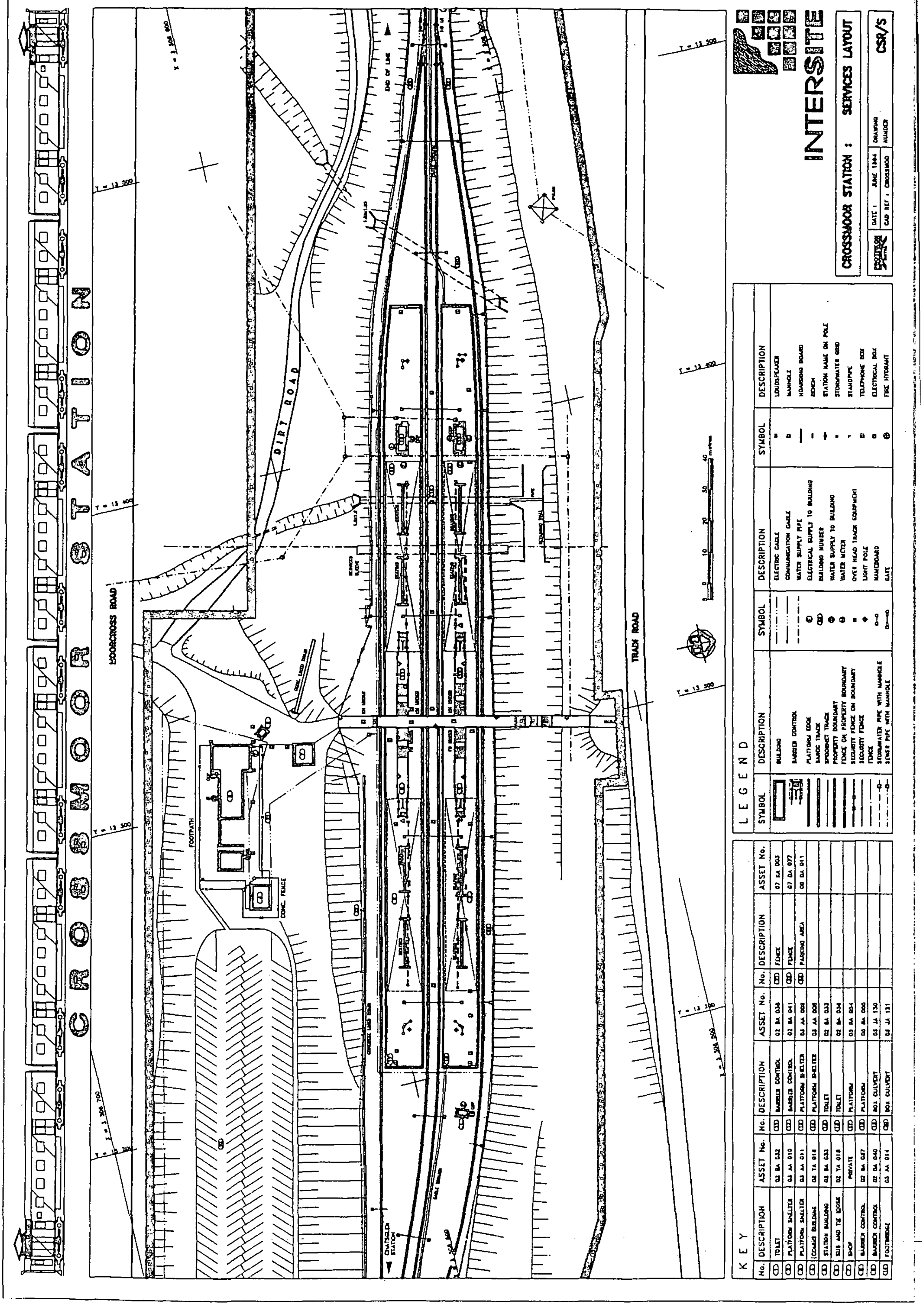


FIGURE 3.9 : Crossmoor Station

At present this line is mainly kept "alive" by the domestic workers and school children from Umlazi and neighbouring areas that work/attend classes in the Chatsworth area. Figure 3.10 which was taken during the am peak revealed that only approximately ten passengers boarded this train at the Westcliff Station.

Figure 3.10 : Poor rail patronage (am peak)

If one looked at the weekly breakdown of commuters entering and leaving the above two stations, it can be seen from Table 3.9 and Table 3.10 that there are less commuters entering the station during the am peak hour compared with those leaving. This survey was carried out during the period 12 May 1995 to 5 June 1995. Residents from the Chatsworth area barely used this line with less than 5% of the commuters making use of this facility confirming the earlier comment that this line was "kept alive" by the school children and domestic workers from Umlazi and neighbouring areas.

TABLE 3.9 : WEEKLY COUNT OF COMMUTERS ENTERING AND LEAVING BAYVIEW STATION (AM PEAK HOUR)

	Sunday	Monday	Tuesday	Wed.	Thurs.	Friday	Saturday
Enter	15	218	227	245	218	196	85
Leave	36	457	479	643	450	384	178

TABLE 3.10 : WEEKLY COUNT OF COMMUTERS ENTERING AND LEAVING WESTCLIFF STATION (AM PEAK HOUR)

	Sunday	Monday	Tuesday	Wed.	Thurs.	Friday	Saturday
Enter	33	412	347	340	314	323	126
Leave	40	540	506	476	479	479	133

Although the scheduled peak hour service at present is only three trains, the potential line capacity is 11 trains, yielding a potential for growth of 265%.

3.3.2 Available Facilities at the Stations.

A survey was conducted to study the facilities available and parking utilization at all five stations. The station car parks were monitored over a period of approximately two months. The percentage utilization of the parking bays at four of the five stations ranged from zero to three percent. Only the Westcliff Station car park revealed approximately ten percent utilization. The Crossmoor Station car park which had a zero percent utilization of bays (Figure 3.11) was currently used as a dumping site.

Figure 3.11 : Crossmoor station car park : zero percent utilization of bays

On a much lighter note, some use was made of the Chatsglen Station car park by one of the residents that operated his welding business whilst another conducted his fruit and vegetable sales from the car park. The Westcliff Station car park was also put to some use by another local businessman that operated a trucking business and needed the extra space to park his trucks. There was no drinking water on any of the platforms and seating was very limited. Some of the toilets were in a very poor condition and unhygienic while some were permanently locked. In some areas, the settlement on the premix section of the platform had resulted in a significant difference in level with the concrete edging of the platform and this certainly posed a danger to commuters. Due to the under-utilization of the parking areas, some of them were used as dumping sites. One of the car parks is currently used as a minibus taxi rank. All stations are easily accessible after hours due to the absence of security. This resulted in vandalism and constant looting of lighting, plumbing and other rail furniture. The station building/ticket office at the Westcliff Station was destroyed by fire (Figure 3.12) on 27 July 1995. According to one of the employees, the company was paid out for the damages, but to date no work towards the construction of the station building had commenced. The present ticket office is a little red fibreglass container (Figure 3.13) with no communication link to any of the other stations or the outside world. This poses a serious problem in the event of an emergency or accident. The makeshift office was prone to flooding and therefore made the sale of tickets very difficult during the rainy days. Commuters was also unhappy with the portable ticket issuing machine since they preferred the standard card form in place of the paper roll type. Rail officials complained of not being informed by staff of other stations in the event of a delay or breakdown.

Figure 3.12 : Westcliff station building : destroyed by fire

Figure 3.13 : Present ticket office : Westcliff station

Only one of the five stations showed the time table for this line but, on close inspection, it was found to be outdated which made it even more difficult for prospective supporters of the system.

On 15 September 1996, the station building/ticket office at the Havenside Station was destroyed by fire. According to the owner that operated a café housed in this building, all equipment and stock was totally destroyed by the fire. The present ticket office is a replica of the one installed at Westcliff Station. What was also very interesting and of serious concern was the lack of fire extinguishers at the stations.

It would appear as if some of the station areas had better bar facilities which generally catered for the unemployed and trouble-makers than the essential facilities to benefit the rail users.

3.3.3. Reasons for the Under-Utilization of Capacity and Current Problems

Based on the survey and the site investigation conducted in the area, it was evident that the community was not consulted regarding the location of the rail system. The number of people residing within 500m of the rail station was determined and expressed as a percentage of the total population. It was found that less than 5% of the total population in this area resided within 500 metres of the rail network reflecting accessibility as one of the prime factors responsible for the under-utilization. The car park at the Chatsglen station is situated more than 200 metres from the station platform and the present utilization of the bays is zero. None of the ticket offices are easily accessible from both sides of the footbridge with the exception of Bayview Station. According to one of the ticket operators, all ticket offices are closed for approximately four hours during the day which again highlights the problem of lack of accessibility and poor frequency of service.

On a much lighter note, the sign reflected in Figure 3.14 caught the author's attention during the on-site investigation. Could this be a contributing factor to the poor patronage on this rail line?

Figure 3.14 : Foot bridge leading to Crossmoor station

More important, in recent years, the alarming escalation of violence and crime had resulted in a distinct shift from rail transport to other modes. The lack of security at the station car parks led to the damage and theft of numerous vehicles and vehicle accessories. Even those commuters that were prepared to walk the extra distance to the rail station in order to benefit from the low fare were constantly mugged. The lack of security at the station building, footbridge and platforms coupled with the dense shrubbery and trees surrounding most of the stations, make them an ideal breeding ground for thugs. It was also revealed that commuters generally waited for a group before boarding the train. This precautionary measure was the result of a recent incident where a rail user was robbed and then seriously stabbed. The sale of liquor at some of the cafes adjoining or next to the station building added to the problem. Labourers apparently seeking casual work, were the prime supporters of this business and also the main perpetrators of crime, violence and intimidation. The tuck shop at the Bayview Station was broken into for the forth time on 4 September 1996. This business had already changed ownership thrice in the last few years. According to the present owner, the station building was guarded by a night watch but since his murder while on duty, the security company had withdrawn. He also commented that very often he had to assume the role of a security officer or even the role of the South African Police Services (SAPS). It was alleged that the small contingent of the South African Police Service's mobile unit which operated sporadically on trains did not prove effective since they preferred travelling first class and therefore avoided the third class where all the violence and robberies occurred.

It was also established that the rail station in Arena Park resembled a war scene recently when a huge explosion wreaked havoc. The ticket office and tuck shop were badly damaged whilst the roof and walls of the building were blown out. Luckily there were no casualties. The incident occurred on the night of 13 March 1997. A police spokesman said if the blast had occurred earlier, the consequences could have been disastrous because of the many commuters who used the service at that time of the day. Police sources also confirmed that the initial investigations indicated that the explosion was not gas or electricity related. This was the third station building in the area to be destroyed over the last two years.

A recent visit to the Bayview station (August 1997) revealed that the tuck shop which is located in the station building was, yet again, under new management. The current owner claimed bitterly about the lack of security after hours and added that his shop was already broken into three times over the last seven months. Due to the poor patronage, he revealed that he was forced to sell "other items" in order to make a living. The most recent break-in was via the ceiling which forced the owner to install burglar guards over the ceilings. He further commented that although his shop was now safer than prison cells, further break-ins was not impossible. His primary request/recommendation to metro rail was to install burglar guards on both sides of the footbridge leading to the station building. On close examination, this appeared to be a reasonable request since this was the only station building in the area that was centrally situated and the installation of gates on either side would prove effective.

It was also observed that most of the school children from neighbouring areas that disembarked at the Westcliff station in the mornings did not use the main access and footbridge leading from the station platform. Instead they walked in the opposite direction, along the rail and then crossed over the railway lines and the Higginson Highway which very often operates at forced flow conditions during this time of the day. Whether this deviation on the part of the pupils had anything to do with fare evasion or whether perceived as a shorter route to school, this certainly posed a serious problem to Metro rail and motorists using the highway. But more important, the school children were placing their own lives at risk. The Chatsworth Spur claimed its latest victim in October this year, when a fourteen year old school girl was crushed to death by an oncoming train while on her way to school. She allegedly did not see the train and was killed instantly on impact. A few months back, a similar incident claimed the life of yet another scholar. Some pupils again gambled with their lives in the afternoons, by sitting on the railway lines or on the platforms with their legs dangling over the lines while waiting for the train to arrive.

In general, the distance to the rail station (accessibility) and the inadequate levels of policing were the primary causes for the under-utilization. The lack of access control, lack of convenient ticket sales offices, restricted hours of ticket sales, inadequate and poor facilities/infrastructure and limited service were all contributing factors. The investigation also revealed various other facets specifically relating to safety that obviously required immediate attention in order to prevent a catastrophic situation from occurring.

3.4 Conclusion

The assessment revealed that the traffic on Higginson Highway (M1) was approaching saturation. The M1 and all major intersections to the Highway showed a significant increase in the number of accidents over the years. Transport infrastructure and related facilities pertaining to bus and minibus taxis were hopelessly inadequate. Metro rail is grossly under-utilized and the available facilities at the stations were found to be inadequate. The under-utilization could be explained by the percentage utilization of the parking bays at four of the five stations which ranged from zero to three percent.

The assessment on the current transport situation showed that much has to be done in order to increase the utilization of the existing public transport infrastructures and services to realise the objective of 80:20 between public transport and private car usage as targeted in the White Paper on National Transport Policy.

CHAPTER 4

COMMUTER PERCEPTIONS OF THE EXISTING TRANSPORT SITUATION

CHAPTER 4

COMMUTER PERCEPTIONS OF THE EXISTING TRANSPORT SITUATION

4.1 Introduction

Based on the assessment of the current transport situation (Chapter 3), it is evident that traffic from Chatsworth area would increase to a point where the capacity of the existing road transportation infrastructure would soon be depleted due to, inter alia, the excessive use of private vehicles. The morning peak hour volume on the Higginson Highway has already increased by 66 percent since 1988 (2926 vehicles per hour to 4863 vehicles per hour) and there is no indications of this trend being reversed or curbed. Rail patronage continued to decline with more than 80% drop in patronage since 1983.

Reasons for the excessive usage of private cars and the steady decline in public transport usage, especially rail, needed to be identified in order to overcome the existing traffic problem experienced on Higginson Highway. Feedback from the residents of the area was necessary and essential in order to assess the overall transportation situation as perceived by the commuter. It was therefore decided to conduct a home interview survey amongst the residents in the greater Chatsworth area in order to establish their attitudes, preferences and priorities concerning the existing transportation situation.

4.2 General Characteristics

The questionnaire (Annexure A) was designed to obtain information pertaining to the socio-demographic profile, mode of transport and specific questions intended for private car users and public transport users. It was decided that the area be divided into thirteen sections or units as reflected in Table 4.1. This was done purely as a mechanism for control and it was realized from the outset that the resources and the time constraints would not permit the collection of data by home interview survey in proportion to the population distribution of the respective units. For the purpose of obtaining a representative sample, it was decided to carry out surveys at randomly selected households. To select the households, a brief count of the total number of residential streets in the area was conducted, revealing 433 streets. The counting was done on a map of the area. Considering all the restraints involved it was decided that 75% of the total number of streets be randomly selected and one household per street be also randomly selected and interviewed. The calculation henceforth was quite straightforward. A total of 325 responses were obtained (75% of 433) with 25 responses per unit (325/13). In just two of the units that had slightly fewer than 25 streets, it was necessary to interview two households on some of them. In this case the length of the street was taken into consideration. For example, in the Woodhurst unit which has 24 streets, two households were randomly selected and interviewed on Woodhurst Drive which is the longest street in this unit.

TABLE 4.1: Survey area reflecting the various units

CODE	NAME
HS	Havenside
BV	Bayview
WC	Westcliff
MH	Mobeni Heights
CD	Croftdene
AP	Arena Park
MF	Montford
KH	Kharwastan
UZ	Umhlatuzana
SG	Silverglen
MT	Moorton
WH	Woodhurst
CM	Crossmoor

The code names used in Table 4.1 assisted with the analysis of the data. It was much easier to use the code names when generating the "frequency tables" and also helped in presenting some of the output. For example, it can be seen from Figure 4.5, which gives the responses from car users that would consider public transport from the different areas, that it was easier to present this graph using the codes.

4.2.1 Questionnaire Format

A questionnaire was designed to carry out home interview surveys to collect the information primarily on the existing travel behaviour of the residents in the study area. It was designed to be filled in by the interviewers from the responses by the respondents. Only questions which were relevant and relate to the objectives of the present study were included. Questions were mostly close-ended, simple, direct and unambiguous.

The questionnaire was basically divided into three categories or sections. The first section covered the more general questions such as the respondents main mode of transport to work, distance from home to his/her workplace and further questions relating to the socio-demographic profile of the commuter. These included specific questions on the number of family members , employed persons, number of cars and average monthly expenditure on transport for the household. A total of eleven questions were covered in this section.

The second category was aimed at private car users. Questions relating to time taken to get to work, their opinions on the time taken and the traffic condition to and from work were asked. They were also asked to indicate the factors that encouraged them to use their cars and to give reasons as to why they did not use public transport. Questions aimed at encouraging car users to consider public transport were also included. A total of eleven questions were structured around this section.

The third and final category was designed to obtain feedback from public transport users. Questions relating to their main mode of public transport, time spent walking to the stop/station, their opinion of the time spent walking and time spent waiting for the public transport to arrive were included. Further questions relating to their opinion on the overall service provided, safety aspects and assessment on the adequacy of the facilities/infrastructure were also covered. A specific question was also designed to obtain input from public transport users with regard to improving their current mode of transport. A total of ten questions were included in this section.

The preliminary questionnaire was circulated among a few experts, who gave their views. A few preliminary surveys were then conducted in the study area in order to get input from the general public. The questionnaire was then finalised for the main survey.

4.2.2. Data Collection

Students studying civil engineering at the M L Sultan Technikon and those seeking experiential training in civil engineering were employed as interviewers. The data collection procedure was explained in detail to the interviewers. The fact that these students were involved in transportation engineering, made the task of explaining the procedure so much easier. The end result verified this since no spoilt questionnaires were obtained. The interviewers were allocated different units/sections in the area as highlighted in Table 4.1. This definitely assisted in having full control of the data collection exercise. The interview surveys were conducted during the months of June 1996 and July 1996. No major problems were experienced although some interviewers were required to call on certain households more than once. This was done purely to accommodate the commuter/respondent at a time that was suitable to him/her.

4.2.3. Quality Control of Data and Consistency Check

As mentioned above, every precaution was taken to avoid obtaining any abnormal data. It was pleasing to note that all data obtained was of satisfaction. The sampling technique adopted ie. coding according to the different units or sections, proved very effective since a good spread of feedback was obtained from both car and public transport users. This further verified the consistency of the data.

4.2.4. Data Analysis

The data was computerised and analysed using SPSS (Statistical Package for the Social Sciences). As previously highlighted, the sampling technique adopted proved effective since a good spread of car users (170) and public transport users (155) were obtained for the analysis. It was pleasing to note that the feedback/response rate was 100% with no rejected questionnaires. However, this was expected since the research assistants were well trained and made every effort to ensure that the questionnaires were completed correctly. All frequency tables were critically examined and the necessary and relevant cross tabulations identified. Some cross tabulations was carried out amongst the units in order to gauge their response/sensitivity on certain issues.

4.2.5 Socio-Demographic Profile

Analysis of the data revealed that more than 90% of the households had from three to eight members in the family with approximately 70% of them having from three to five members. 52% of the households had one employed person while 33% of the families indicated two employed persons per household. Table 4.2 reflects the number of family members in the household to the number of employed persons in the household. It was also interesting to note that 5% of the households interviewed had from six to eight members in the family with only one employed person. Approximately 83% of the families interviewed had school and/or college going members obviously indicating a high employment demand in the future.

TABLE 4.2 : Number of family members to the number of employed persons in the household (Overall percentage respondents)

Family Members	EMPLOYED PERSONS					
	NONE	1	2	3	4	4+
<3	0.3	4.1	1.2	0.0	0.0	0.0
3-5	0.6	42.2	20.6	4.6	1.5	0.0
6-8	0.9	4.6	10.2	5.9	0.9	0.6
9-11	0.0	0.0	0.6	0.3	0.0	0.0
11+	0.0	0.6	0.0	0.0	0.3	0.0

Table 4.3 shows the number of cars owned per household in relation to the mode used by the respondent. Just over 80% of the households own at least one motor vehicle indicating a high car ownership in the area. Further calculations reveal a car ownership of approximately 300 cars per 1000 population. It can be deduced from Table 4.3 that 68% of taxi users have at least one vehicle in the household. Similarly, 66% of bus users and 40% of rail users have at least one vehicle in the household. If the car ownership pattern can be considered as a reflection of the income level, it is clear that the train users are from the poorer section of the community.

TABLE 4.3 : Car ownership in relation to mode used by the respondent (Percentage respondents based on individual modes)

MODE	NUMBER OF CARS				
	NONE	1	2	3	3+
Car	1.8	61.8	30.0	5.9	0.5
Bus	34.3	53.9	9.8	2.0	0.0
Taxi	31.6	50.0	13.1	5.3	0.0
Train	60.0	33.3	6.7	0.0	0.0

1.8% of the respondents travelled by car to work although they did not own a motor vehicle. It was most likely that they shared a lift with a colleague and perhaps contributed towards the fuel and operating costs of the vehicle.
Table 4.4 shows the age structure of the commuters that were interviewed in the survey area. Approximately 74% of the present employment force range between 26 years and 45 years. This obviously did not include the responses from students since they were not considered as employed persons.

TABLE 4.4 : Age structure of respondents interviewed

AGE	Below 20	20-25	26-35	36-45	46-60	Over 60
% Respondents	4.6	14.5	27.4	41.5	10.5	1.5

Figure 4.1 reflects the occupation of the respondents. Just over 10% of the respondents fell into the professional category with a substantial percentage (72%) in the skilled white and blue collar category.

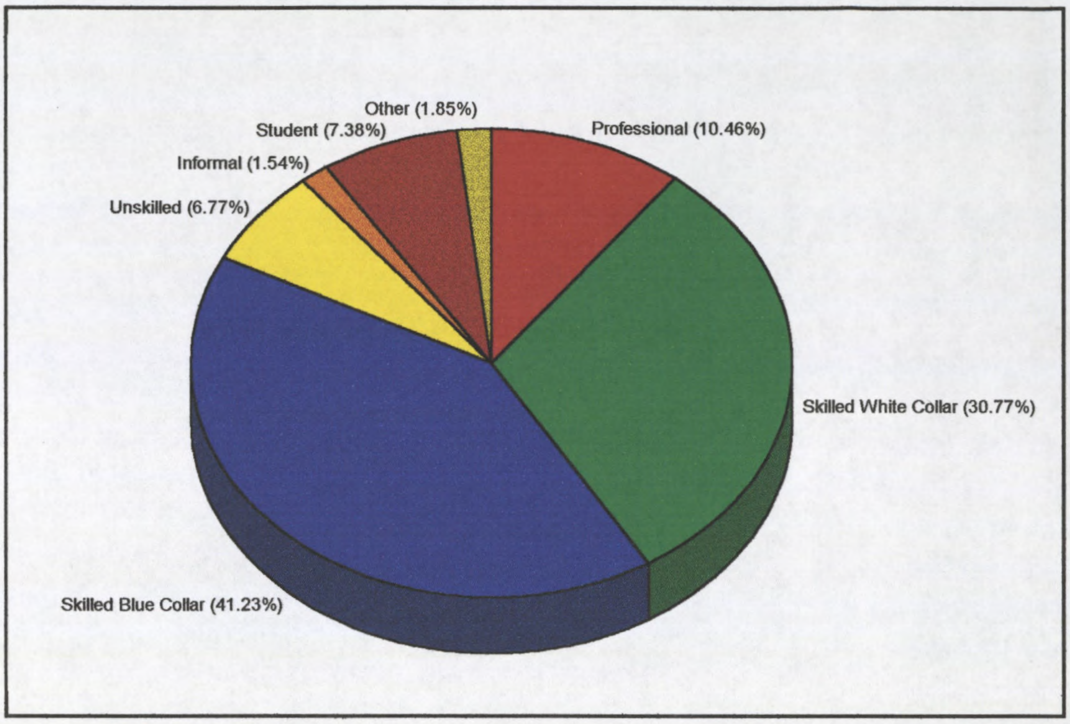


FIGURE 4.1 : Occupation of respondents

27% of the respondents were females, reflecting a significant proportion of females in the employment sector. The main mode of transport for males and females are highlighted in Figure 4.2 . There were more female respondents from the Arena Park, Montford and Crossmoor areas compared with the other units/sections. A significant proportion of the females travelled by motor cars or used the bus system. Only 1% of the female commuters travelled by rail. Even the male commuters generally preferred the private motor vehicle with the bus system receiving greater support amongst the public transporters.

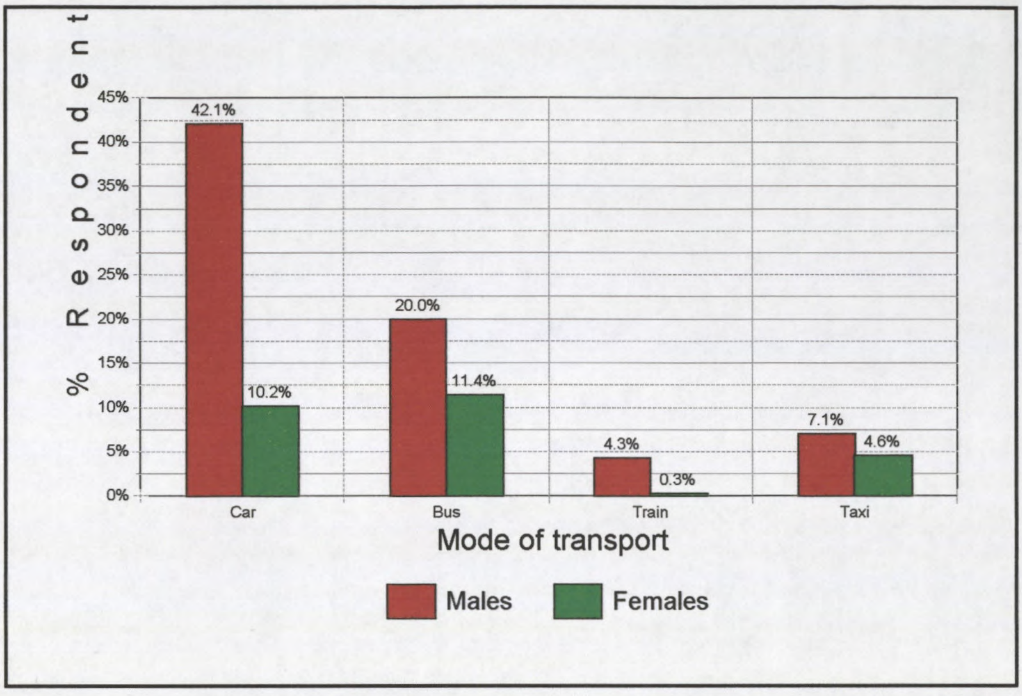


FIGURE 4.2 : Main modes of transport for male and female commuters

Based on the feedback, the average family net income was estimated at R3000 per month. On average, approximately 14% of the family's net monthly income was spent on transport. It was evident that in most cases, the family net monthly income was directly proportional to the monthly expenditure on transport ie. the higher the family net monthly income , the higher the expenditure on transport for the month. This could be attributed to the usage of private motor vehicles. 94% of the families that earned between R1000 and R2000 per month spent up to a maximum of R300 per month on transport. On the other hand, 60% of the households that earned more than R5000 per month spent well above R400 per month on transport with 25% of them indicating a monthly expenditure of more than R600.The major percentage of the households (63%) received a net monthly income of between R2000 and R4000 while 20% of the families earned a net monthly income of less than R2000. On average, 25% of the families spent more than R400 per month on transport while 56% of the households spent between R200 and R400 per month on transport. Only 19% of the families spent less than R200 per month on transport.

66% of car users indicated a family net income of more than R3000 per month compared with 47%, 26% and 7% of taxi, bus and rail users respectively. As expected , the monthly expenditure on transport per household was much greater in the case of car users as compared with public transport users (Table 4.5). With regard to public transport users, it was evident that rail was the cheapest of the modes.

TABLE 4.5 : Mode of transport versus Monthly expenditure on transport per household (percentage respondents based on individual modes)

MODE	MONTHLY EXPENDITURE ON TRANSPORT PER HOUSEHOLD					
	<R200	R200-R300	R301-R400	R401-R500	R501-R600	R600+
Car	6.5	17.1	32.9	27.6	9.4	6.5
Bus	39.2	36.3	18.6	1.0	2.0	2.9
Taxi	13.2	65.8	15.8	2.6	2.6	0.0
Rail	26.7	60.0	13.3	0.0	0.0	0.0

If one had to look at a distance of between 21-30km which is within the Durban CBD range, it was found that 63% of car users indicated that the monthly expenditure on transport for the household was between R300 and R500. This percentage was much lower for bus (35%) and taxi (29%) users with none of the rail commuters monthly expenditure as high as the stipulated range. Figure 4.3 reflects the modal split amongst the residents:

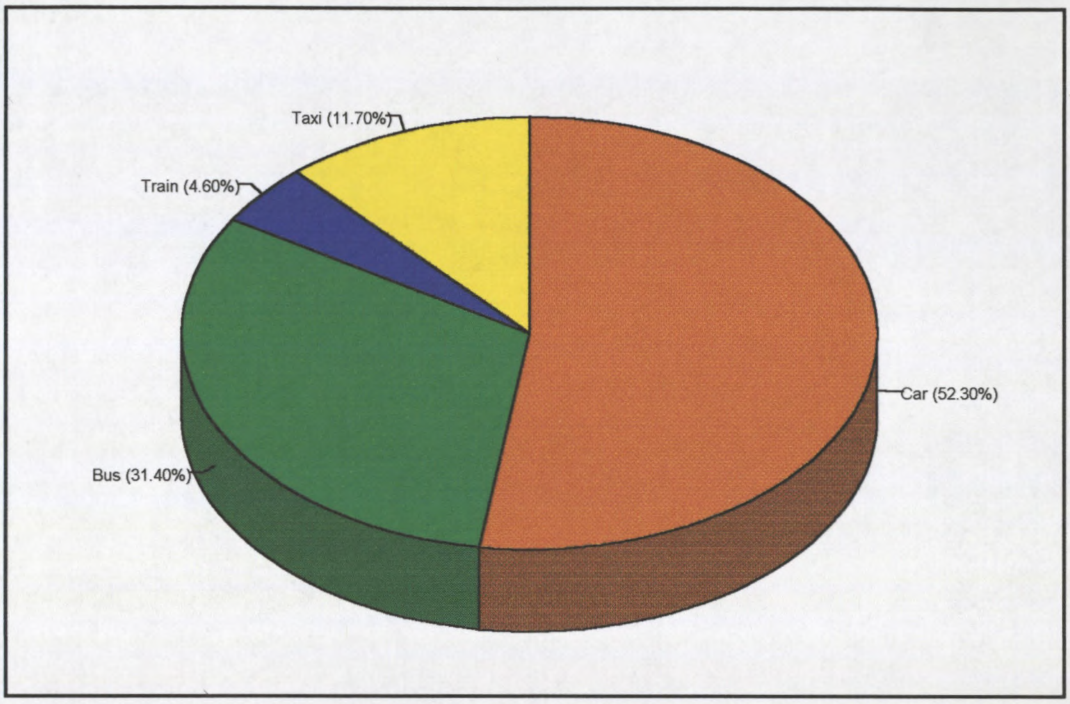


FIGURE 4.3 : Main modes of travel

In spite of the frequent traffic congestion on the Higginson Highway (M1), a high percentage of the commuters (52,3%) still preferred using their motor vehicles to work. However, a significant proportion of the commuters (47,7%) still relied on public transport.

56.4% of car users were either professional or skilled white collar employees as compared with 27.4% (bus), 26.3% (taxi) and 0% (rail). Table 4.6 reflects the occupation of the respondents based on the mode of transport. Note the close correlation between the bus and taxi users with regard to their occupation and choice of mode.

TABLE 4.6 : Mode of transport versus Occupation of respondents

MODE	OCCUPATION OF RESPONDENTS (%)						
	Professional	Skilled White Collar	Skilled Blue Collar	Unskilled	Informal Sector	Student	Other
Car	18.2	38.2	34.7	1.8	1.8	4.7	0.6
Bus	2.0	25.4	45.1	10.8	1.0	10.8	4.9
Taxi	2.6	23.7	47.4	13.1	0.0	13.2	0.0
Rail	0.0	0.0	73.3	20.0	6.7	0.0	0.0

4.2.6 Feedback from Car Users

The main reason for using cars included convenience, reliability and safety. They felt that public transport in general was not reliable, too crowded (bus/taxi) and the total journey time was too long. The aspect of safety, frequency of service and accessibility was also high on the priority list.

With regard to car users approximately 50% of the commuters took between 21-30 minutes to travel a distance of between 11-20km while 40% of the respondents took between 31-40 minutes to travel a distance of 21-30km. Just under 50% of the respondents felt that the time taken to get to work was dissatisfactory to highly dissatisfactory. Figure 4.4 reflects their opinion of the traffic condition to and from work. 85% of them assessed the traffic condition to and from work as congested to highly congested.

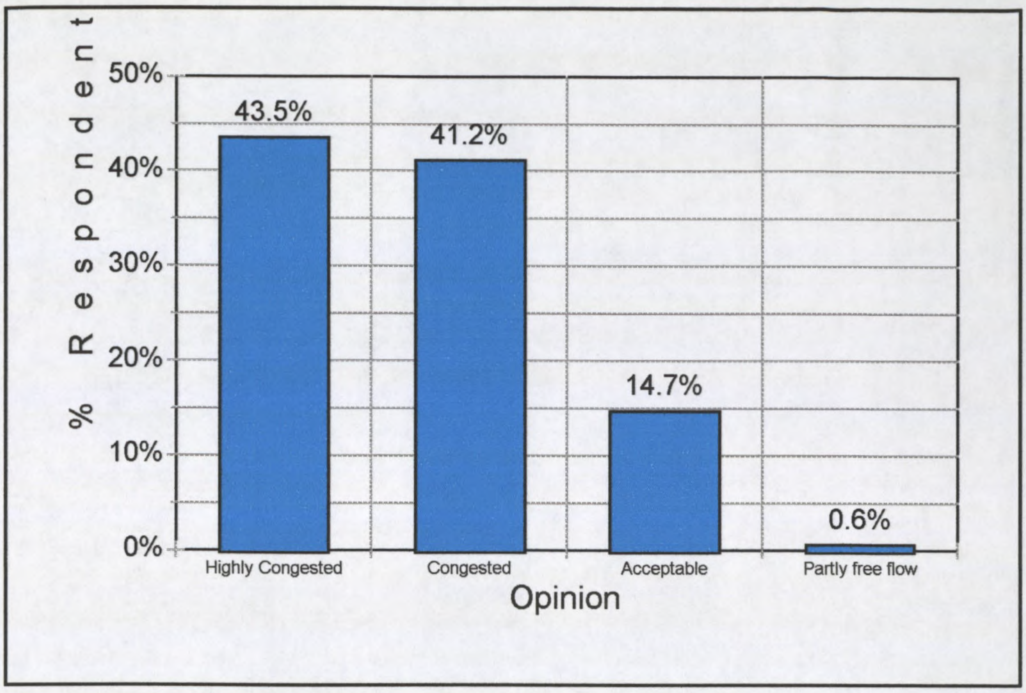


FIGURE 4.4 : Opinion of the traffic condition to and from work

However it was interesting to note that approximately 80% of the present car users indicated that they would prefer public transport if the existing conditions were improved. Figure 4.5 revealed their responses from the different units/sections with regard to using public transport.

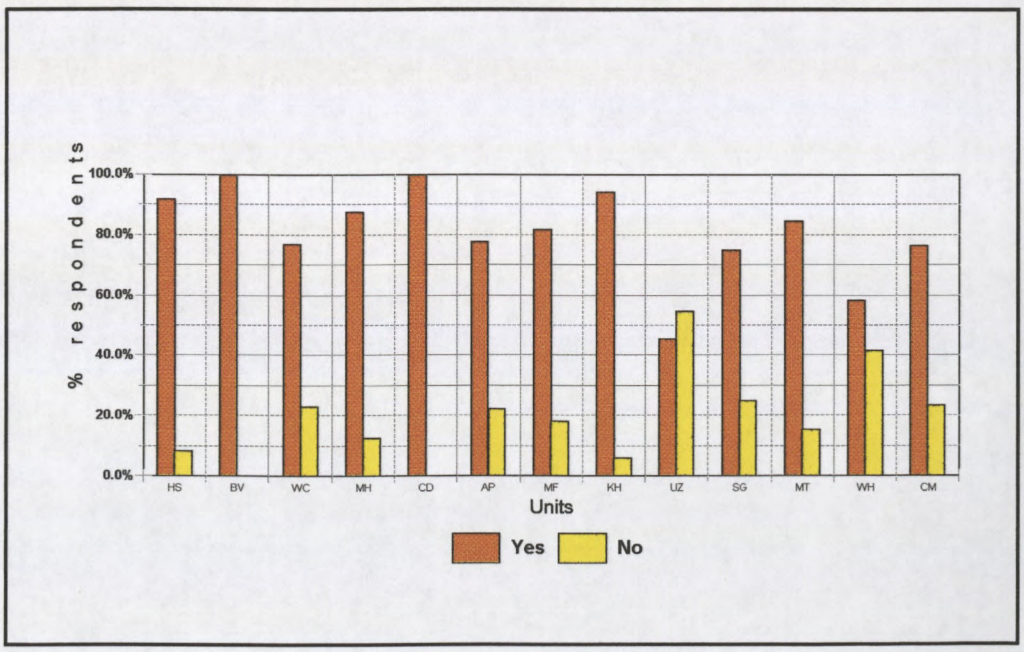


FIGURE 4.5 : Car users that would consider public transport

61% of the "yes" respondents indicated that they would consider bus, 32% would prefer the taxi and 7% would consider rail. However one must bear in mind that the existing conditions played a major role in their choice of mode.

72% of car users considered less than 100m as an acceptable walking distance at the origin and destination ends of public transport stops/stations. 19% of the respondents were prepared to walk up to 200m. With regard to waiting time for the public transport, 60% of the car respondents considered up to 10 minutes as acceptable while 39% of them were willing to wait up to 15 minutes.

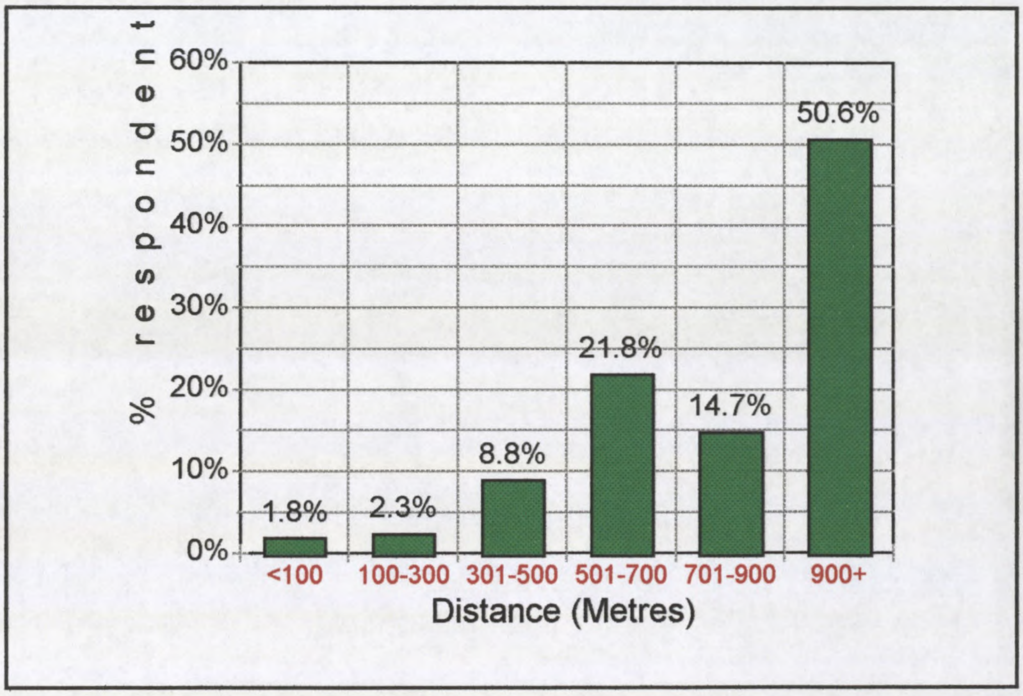


FIGURE 4.6 : Nearest rail station (car users)

The distances of the nearest railway stations for those respondents that use cars were obtained as shown in figure 4.6. It shows that approximately 87% of them reside more than 500m from the rail station. The factors that all car users considered most important to be improved on the rail service for them to consider rail included: secured parking at the station, security while travelling, improved frequency of service and minibus service from their locality to the station and destination station to their workplace.

It was also encouraging to note that 64% of the families that presently owned motor vehicles had at least one member of the family use the public transport system. Perhaps some of them have no option but to use the public transport system since they don't have access to another vehicle. In the case of two or more employed persons per household, it was possible that they worked in different areas and therefore found it not viable to share the motor vehicle. Bearing in mind that over 80% of the households own at least one motor vehicle with 52% of the families having just one employed person, it was possible that some percentage of car owners used the public transport . An improvement to the public transport system will certainly secure the existing public transport patronage by preventing non-car owners from purchasing their own vehicles as well as encouraging additional car users to the public transport facility.

4.2.7 Response from Public Transport Users

Since the area is inhabited by people of different income groups, a substantial percentage of the residents still rely on public transport. With regard to public transport users only, approximately 90% of the commuters used the bus and minibus taxi service. Figure 4.7 reflects the public transport modal split.

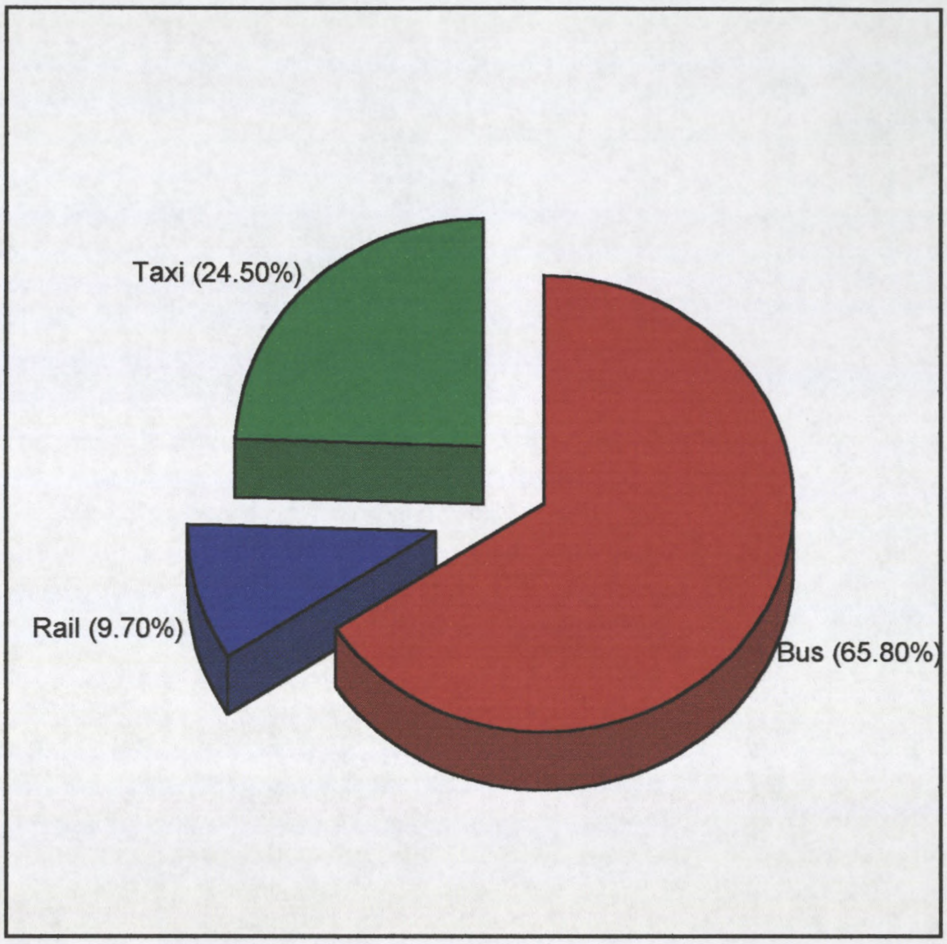
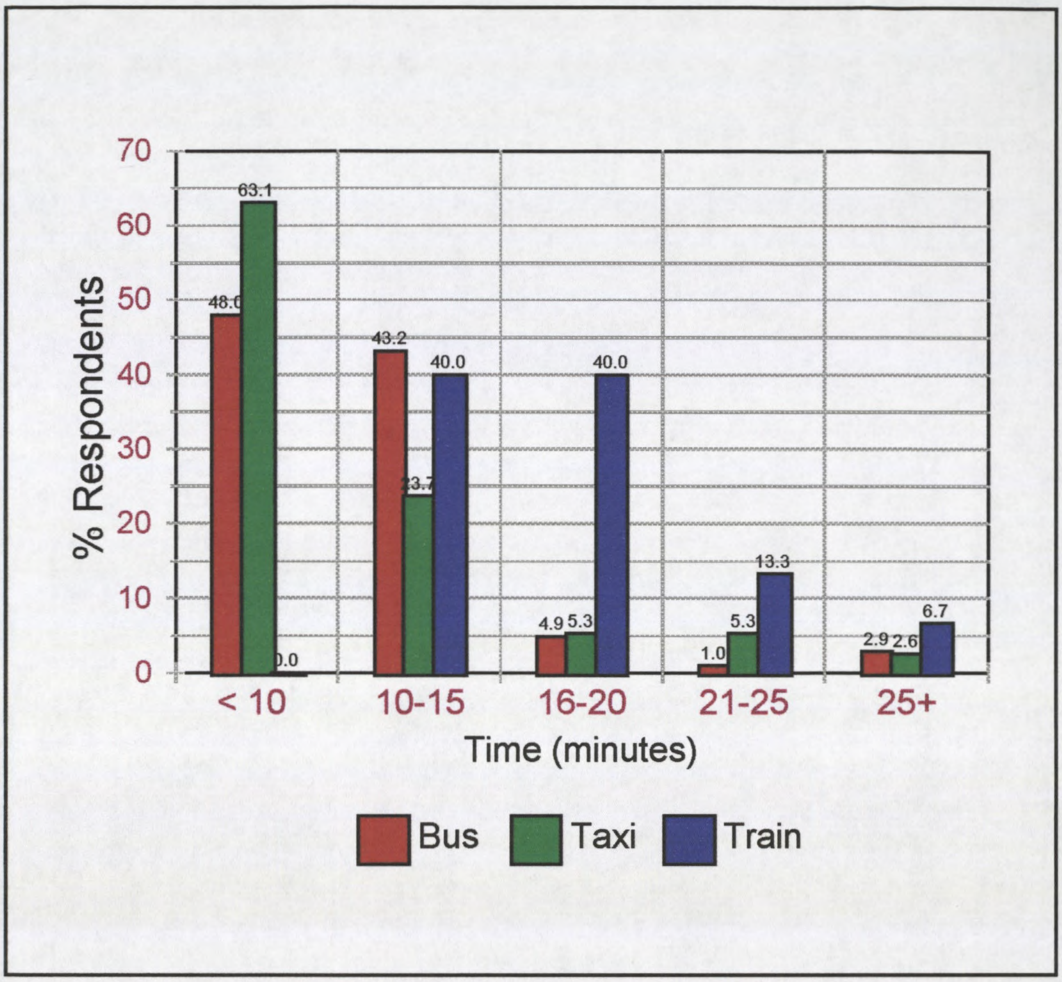


FIGURE 4.7 : Public transport modal split

The present rail users were extremely dissatisfied with the time spent walking to the station once again reflecting lack of accessibility as one of the main reasons for the poor patronage. 80% of the rail commuters took from 10 to 20 minutes to walk to the station. The remaining 20% of the rail respondents took more than 20 minutes which is indeed a significant proportion when compared with 8% and 4% for taxi and bus commuters respectively. The time spent walking to the stop/station for the various modes of public transport are shown in figure 4.8.



<u>FIGURE 4.8 : Time spent walking to the stop/station</u>

In fact 100% of the rail users were dissatisfied to highly dissatisfied with the time spent walking to the station compared with 44% of the bus users and 29% of the taxi commuters. Their opinion of the time taken to walk to the nearest stop/station was reflected in figure 4.9.

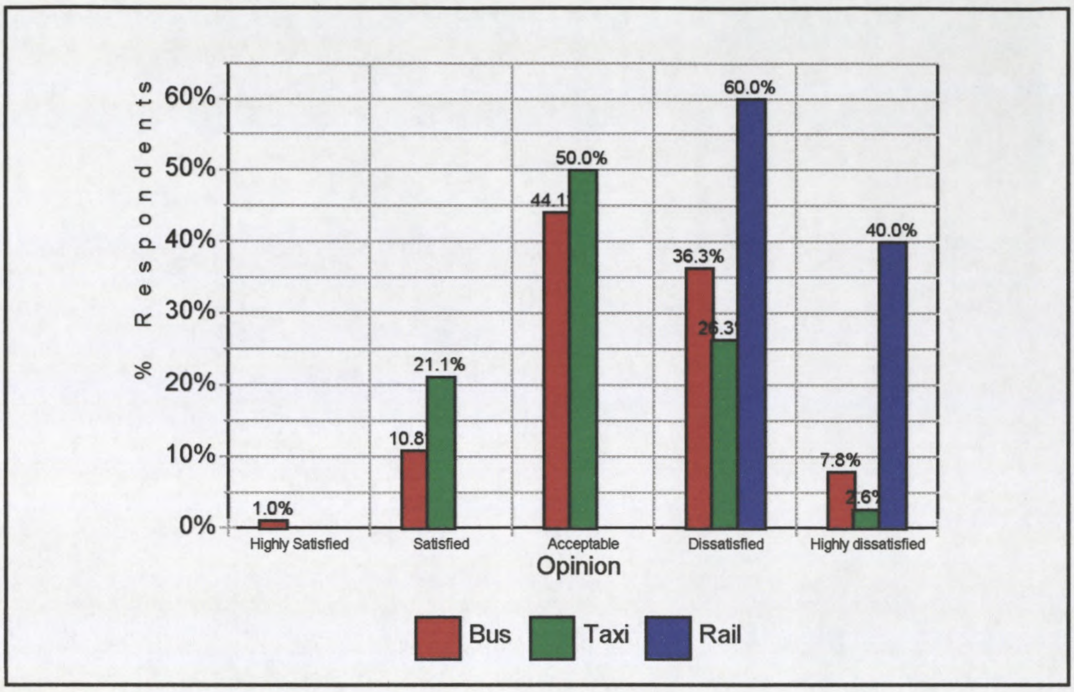


FIGURE 4.9 : Opinion on the time taken to walk to the nearest stop/station

56% of the commuters waited up to 10 minutes at the beginning of the work trip for the public transport to arrive, while 26% of the respondents waited up to 15 minutes. The situation was not any different at the destination end with 68% of the commuters having to walk up to 10 minutes to work from the station/stop while 23% of them spent up to 15 minutes walking. 45% of public transport users took from 31 to 40 minutes to travel a distance of 21 to 30km. However this did not include the time spent walking to the stop/station, waiting for the public transport to arrive and time spent walking from the stop/station to their workplace. Hence the total journey time could be well within the 45-60 minute range for the stipulated range of distance travelled. 64% of all public transport commuters were unhappy with the overall service provided.

Rail commuters showed greater dissatisfaction (figure 4.10) with regard to the overall service provided as compared with bus or taxi commuters. More than 90% of the rail commuters rated the overall service as very poor.

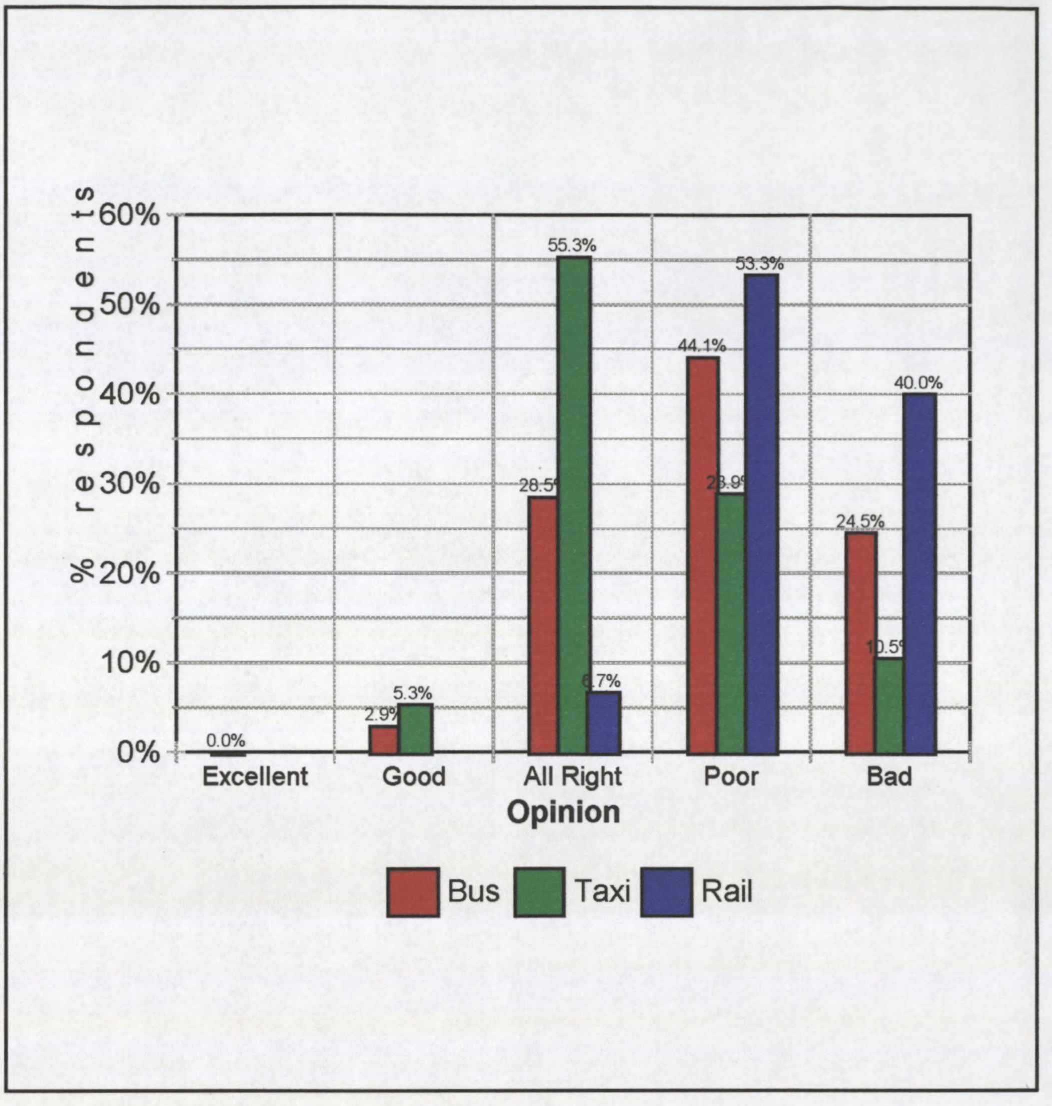


FIGURE 4.10 : Opinion on the overall service provided

A much greater percentage (67%) of rail commuters compared with taxi (45%) or bus (29%) respondents rated the safety aspect as dissatisfactory to highly dissatisfactory (figure 4.11).

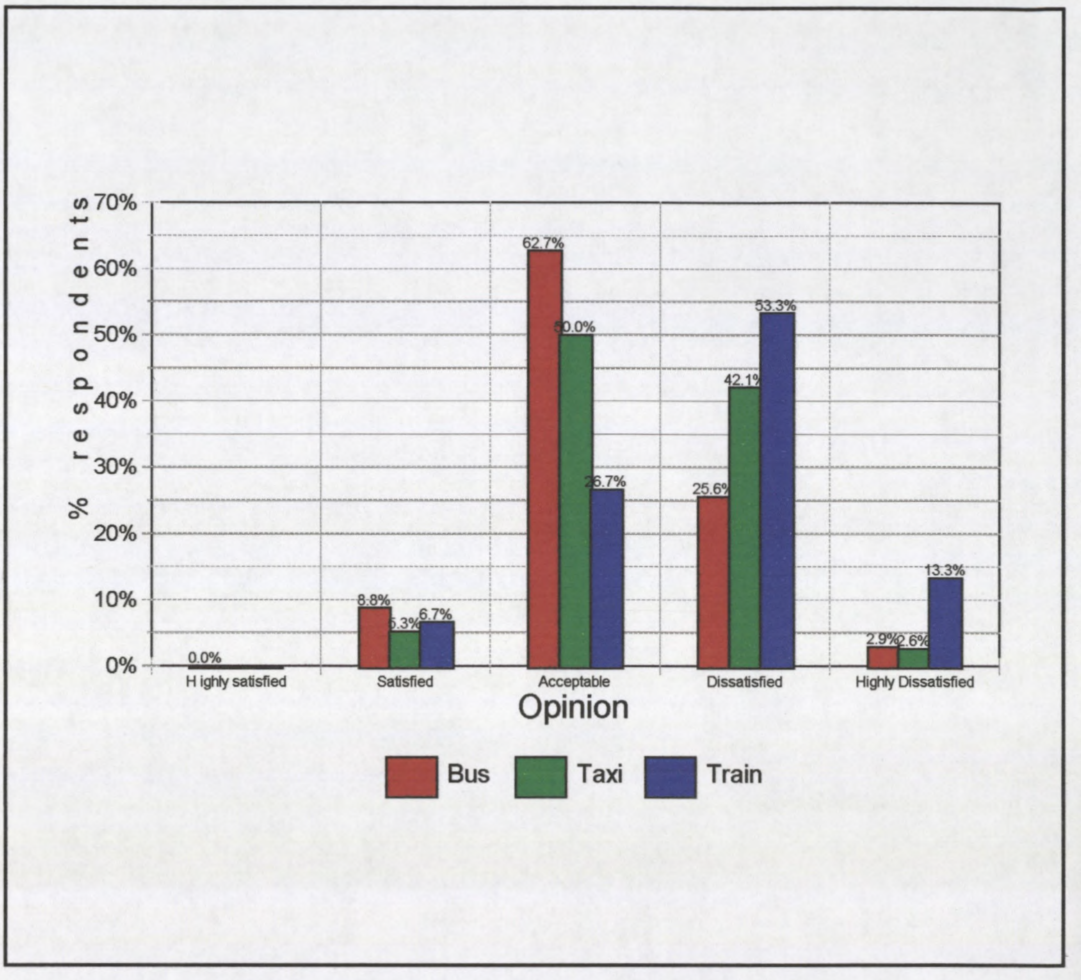


FIGURE 4.11 : Opinion on the safety aspect

With regard to adequacy of facilities/infrastructure more than 80% of all public transport users expressed their dissatisfaction. This was one of the few outcomes where all bus, taxi and rail commuters were in total agreement that serious attention be given to this issue. Figure 4.12 reflects their assessment on the adequacy of the facilities/infrastructure provided for the various public transport .

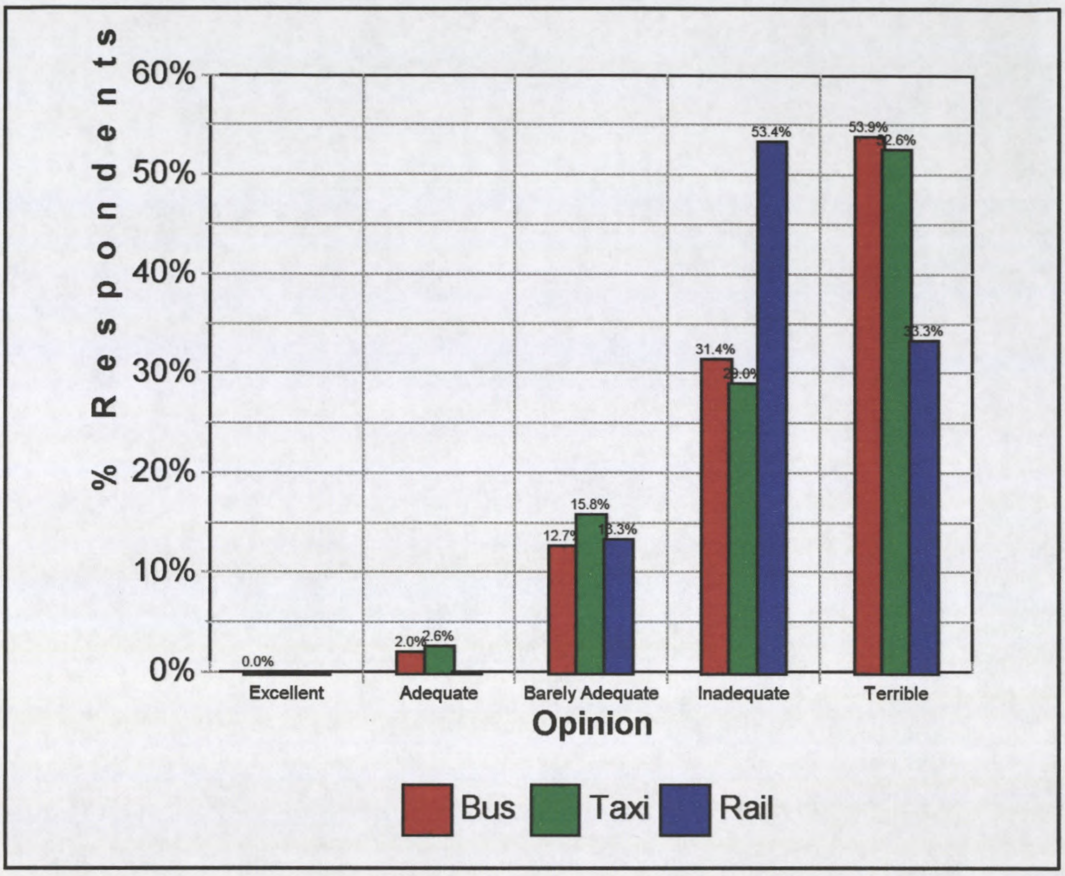


FIGURE 4.12 : Assessment on the adequacy of the facilities/infrastructures

Bus and taxi users considered reliability, frequency of service and comfort as most important to be improved while rail commuters considered reliability, accessibility and safety as important factors to be improved. It was also interesting to note that most of the rail respondents were from the Bayview, Westcliff, Woodhurst and Havenside area. This was obvious and acceptable since these units/sections were closer to the rail station as compared to the other units.

It was evident from the complete analysis that the rail users showed greater discontent in comparison with bus and taxi commuters. It showed that the level of service provided by the rail system was generally much lower than that provided by bus or taxis.

4.2.8 Additional Comments

The questionnaire did allow for any additional comments that the respondent considered important and relevant to the study. However, only 15% of the total number of respondents supplied additional comments. The reason for the limited feedback could be either due to sheer "laziness" on the part of the respondent since this was the last and only open ended question that required some writing or perhaps, according to the respondent, all relevant questions were already covered. Nevertheless, their comments were recorded, based on a more informal or unstructured format. Although every effort was made to highlight these comments in the words of the respondent so as to avoid any bias, it was necessary and logical to condense or summarise some of the comments in order to prevent a repetitive and lengthy report. This approach also substituted for some of the obscene language and remarks levelled at public transporters by expressing the respondents views in a more "amiable" tone.

Having scrutinized the comments it was disclosed that many of them were already covered in the questionnaire and rated by the respondent. This certainly confirmed that the overall structure of the questionnaire was positive. However a few personal experiences and comments by the respondents are highlighted.

The issue of overloading of the buses and taxis but more especially the buses during the morning and afternoon peaks was again emphasized. Many of them complained that public transport in general was not "readily available" during the off peaks. Some bus commuters again expressed their serious concern regarding the long journey time to get to work and back while two of them complained about the variation in the fare. One of the respondents commented that the inner circle taxi took too long to get to the Chatsworth Shopping Complex because the driver spent more time looking for passengers and at times deviated from the scheduled route. The arrogant attitude of some of the bus/taxi drivers and conductors was exposed by a few commuters. The on going debate regarding the loud music on buses and taxis was revived by some users.

One of the bus commuters went even further by commenting on the lyrics of some of the songs played, which he considered as undesirable and unsuitable for his listening pleasure.

Without fail, the safety aspect also made its mark under the additional comments, although previously assessed, but with a few personal experiences. The substantial drop in rail patronage was evident enough that many of them changed to other modes of travel. This was supported by the comments made by some of the car users that previously used the rail service but was forced to change modes after their vehicles were broken into at the station car park. One of the rail users displayed his poetic talents by describing the prevailing eerie atmosphere that surrounded most of the stations. Car users, as well as bus and taxis users confirmed switching from rail and recorded their personal experience on crime. One of the residents from the Kharwastan section who used his motor car to work complained that it would take him almost an hour to walk to the nearest rail station and he was not prepared to park his car at the station. Two of the car users objected to the buses and taxis "stopping anywhere" thus causing traffic friction and congestion. One car user felt that the solution to the traffic congestion on the Higginson Highway was to extend the width of the road and increase the number of lanes while another recalled the long standing demand for a second access road. In spite of the few "expensive" suggestions made by them, it was evident from the complete survey that most of the car users (80%) was indirectly conscious of the present emphasis of the Government of South Africa on economic efficiency and the need to make optimum utilization of the existing infrastructures.

4.3 Commuter Perceptions of Personal Security on Rail Transport

The home interview survey revealed that a greater percentage (67%) of rail commuters compared with taxi (45%) or bus (29%) respondents rated the safety aspect as dissatisfactory to highly dissatisfactory (figure 4.11). Bearing in mind that travel decisions made by commuters are very often based on their belief and perceptions about crime and not really on a detailed knowledge on crime statistics or personal experience (direct or indirect) , it was decided to test the feedback obtained with regard to safety on rail transport. The whole purpose of this exercise was to determine whether there was an urgent need to increase the levels of safety experienced by rail commuters. A simple and straightforward questionnaire (Annexure B) was designed in order to assess whether the respondent or a family member personally experienced any crime, witnessed any violence/crime or heard of any criminal incidents from others. The questionnaire also allowed for any feedbacks or comments with regard to making the rail system more safe. All the questions were related to their work trip while using the rail system.

It was decided that two of the five stations be randomly selected and ten commuters at each of the two stations be also randomly selected and interviewed. The analysis of the data obtained from the twenty respondents revealed that 50 percent of them or a family member either had a personal experience on crime or witnessed some form of criminal activity taking place. Focusing just on personal experiences, 35 percent of the respondents or a family member was affected. Robbery, in some cases associated with assault, was the most mentioned crime. Wallets, clothing (jackets), gold rings and chains seem to be the most wanted items. 35 percent of the commuters were witness to violence and criminal activities which mainly occurred on the trains. Act of violence and intimidation by labourers apparently seeking casual work was again high lighted. They were the prime supporters of the liquor business that operated at some of the cafés situated at or next to the station building. At least three of the respondents mentioned that the 15h50 train from Berea station bound for Chatsworth was a "soft target". 95 percent of the respondents indicated that they heard of criminal incidents from others. These included mainly robbery, pickpocketing and assault. Three of the commuters made reference to an incident where all the commuters in one coach was robbed. Apparently the robbers boarded at the Westcliff Station, made a "clean sweep", before leaving at the Umbilo Station. Fridays seem to be the critical day when most of the robberies occurred for obvious reasons. This was the comment made by one of the respondents who also added that the rail patronage on Fridays was significantly lower than other week days.

With regard to making the rail system more safe, virtually all the commuters emphasized the need for strong security on trains as well as at the stations. Other suggestions included the provision of mobile police stations, installation of metal detectors at platform entrances, "roving" technique to be adopted by the police instead of confining themselves to the first class coach, displaying of crime stickers and greater presence of security during the off-peaks.

With the steady decline in rail patronage over the years, it is quite possible that many of the rail commuters changed to other modes of transport from either fear of crime or even due to their personal experiences. However, cognizance must also be given to the fact that the home interview survey revealed that a significant percentage of the respondents also cited accessibility, comfort and frequency of service as important factors that needed to be improved with regard to rail travel. Present rail users mentioned the lower fare and the close positioning of their workplace to the station (destination end) as incentives for using the system. One of them commented that safety and security was not guaranteed on any mode or for that matter at any place. Nevertheless, based on the findings, it would appear that the safety factor undoubtedly features high on their priority list and therefore warrants thoughtful attention.

4.4 Conclusion

The research findings revealed a high level of economic activity with a substantial increase in the car ownership since the 1991 census which reflected a car ownership for the area of 190 cars per thousand population. The present study revealed a car ownership of 300 cars per thousand population. The average monthly household income also increased from R2020 to R3000. In general car users expressed their dissatisfaction with regard to the frequent traffic congestion on the Higginson Highway but were influenced by factors relating to convenience, reliability and safety. Public transport users showed varied levels of disappointment depending on the specific issues and mode of public transport, with rail users being the least satisfied. With regard to commuter perceptions on personal security on rail transport, the survey revealed that virtually all the commuters emphasised the need for strong security on trains as well as at the stations. Overall a more effective and efficient public transport system was essential to not only retain existing commuters but to effect a shift from private to public transport. Improvements on the aspects identified by the residents is of extreme importance in order to initiate this change.

CHAPTER 5

DEMAND ANALYSIS OF THE STUDY AREA

CHAPTER 5

DEMAND ANALYSIS OF THE STUDY AREA

5.1 Introduction

One of the focus of this case study was to also demonstrate the sensitivity of the integrated system proposed for the study area with regard to population, employment, capacity, frequency of service and the various other elements that may impact on the system. It is important to have some estimate of the future total demand in the study area in order to obtain the optimum allocation of minibus taxis serving the rail network. The capacity of the rail system is equally important in order to be able to satisfy the demand for the proposed integrated system. The level of demand during the peak period was used to calculate the peak fleet requirement.

One should be able to distinguish between the capacity of the road network and the capacity of the transit system. The capacity of a road is its ability to carry traffic and is measured by the maximum number of vehicles that may pass a given point of a lane of the road in one direction during a specified time (usually taken as one hour). Road capacity may be better appreciated through an analysis of the relationships between the speed, flow and density of traffic. The capacity of a transit system is usually measured by the maximum number of persons that can be moved on a single track or single lane in one hour. It is important to determine whether a line can handle peak hour demand.

5.2 Employment Demand

According to the 1991 census figures, the population for the greater Chatsworth area was approximately 200 000. Considering a 10% growth, the present population would be approximately 220 000. The recent home interview survey conducted in the area revealed an average household size of six members with an average of approximately two employed persons per household. Based on the above, the number of employed persons in the study area would be approximately 73400. The employment force wishing to use the integrated system during the peak hour will help determine the service requirement of both public transporters.

5.3 Vehicle Capacity

The capacity of a taxi/train route is the product of the passenger capacity per taxi or train and the maximum number of taxis or trains that can travel on the route during a specified period of time.

According to the Chatsworth Minibus Association, approximately 300 taxis are operating on the inner circle route (ie. in the greater Chatsworth area) with a smaller proportion allocated to the Durban CBD route. For the purpose of this study, the Toyota Hiace (Super 16) was chosen as the representative vehicle since it was found that a high percentage of the taxi operators used this vehicle. This minibus has a Toyota 4Y engine (capacity of 2,237 cubic centimetres), 2495 mm wheelbase, an overall length of 4725 mm and a gross vehicular mass of 2650 kg. Based on a maximum of 300 taxis engaged in the integrated system, the total number of passengers per trip transported to the stations will be 4800 (based on a capacity of 16 passengers per taxi).

The capacity of rail transit may be expressed as the maximum number of passengers that may be carried by the system in one hour per track in one direction.

The capacity is given by:

$$Cm = 60W/hf$$

where: Cm = capacity expressed as number of passengers per track in one hour in one direction.

W = crush load ie. maximum number of passengers per train during peak hour.

hf = headway in frequency of train movement along the track per minute.

W depends upon the size of each coach and the number of coaches per train. The present fleet operating on the Durban-Crossmoor line consists of 5 train sets with a total of 9 coaches per set. Each motor coach can haul a maximum of 3 trailer coaches. The number and composition of made up train-sets operating on the Durban - Crossmoor line is shown in Table 5.1. The table also reflects the number of motor coaches and plain trailers that were used to make up the sets.

Table 5.1 Train-Set Make-Up : Durban-Crossmoor Service

# of Train-Sets	Motor Coaches		Plain Trailers		Total # of Coaches
	1st Cl.	3rd Cl.	1st Cl.	3rd Cl.	
5	1	2	1	5	9

Source: Metro Rail, Durban 1994

Motors and trailers are either first or third class, the difference being in terms of the number and quality of seating provided as well as the standard of lighting.

The passenger capacity per train set on the Durban-Crossmoor line is equal to 1210 (normal) and 1515 (crush load) where the crush load is equal to approximately 25% more than the normal load (Source: Metro Rail, Durban 1994). There is considerable potential to increase the frequency of service provided on this line. The scheduled peak hour service on the Durban-Crossmoor line is made up of three trains with a passenger capacity of 4545 (Metro Rail, Durban 1994). The potential line capacity is equivalent to 11 trains with a passenger capacity of 16665 at peak hour yielding a potential growth in capacity of approximately 265%. Table 5.2 gives the passenger capacity for the varying peak hour services based on "crush" loads. It can be deduced from the table that if the number of trains were increased during the peak hour, a substantial number of commuters could be accommodated by metro rail. For example, if the number of trains during the peak hour was doubled ie. to six trains, the passenger capacity will increase from 4545 to 9090. It could also be possible to increase the size of the train-sets to 14 coach sets, the capacity of the service provided could be increased by approximately 55%.

Table 5. 2: Varying Peak Hour Service vs Passenger Capacity

Number of Trains (Peak Hour)	Passenger Capacity
4	6060
5	7575
6	9090
7	10605
8	12120
9	13635
10	15150

5.4 Integrated System Demand

The main modes of transport to work as determined from the commuter survey conducted in the area are reflected in Table 5.3

Table 5.3 Main Modes of Transport to Work

Mode	Percentage
Car	52.3
Bus	31.4
Train	4.6
Taxi	11.7

It can be seen from the table above that a high percentage of the commuters (52.3%) still preferred using their motor cars, in spite of the frequent traffic congestion on the Higginson Highway (M1). However, a significant proportion of the commuters (47.7%) still relied on public transport.

It was also interesting to note that 80% of the present car users indicated that they would consider public transport if the existing conditions were improved. However, bearing in mind the Government's objective of promoting public transport with the goal of achieving a ratio of 80:20 between public transport and private car usage, as a long term vision, it is very unlikely for such a high percentage to make the change over a short period of time. Keeping this in mind, it was decided to look at the impact on the integrated system based on a more realistic demand of say between 5% and 20%. Table 5.4 reflects the total demand on both the public transport modes assigned to the integrated system (IS) during the peak hour. It was also assumed that the total employment force was confined to the Chatsworth - Durban CBD corridor.

Considering the above scenario, if say 10% of the present car users, as well as taxi and bus users were to opt for the integrated system, the percentage demand will be 0.1 * 52.3 + 0.1 * 31.4 + 0.1 * 11.7 + 4.6 (no shift in present rail patronage) ie. just under 15% of the employment force will be absorbed by this system yielding approximately 11000 commuters that will need to be accommodated. Based on 300 minibuses allocated to the integrated system, all 300 taxis will be required to make two trips to the designated stations with approximately 88 taxis having to make an additional (3rd) trip. The number of trains required during the peak hour will be 8 trains at headway of approximately 7.5 minutes (based on a crush load capacity of 1515). Table 5.4 also reflects the demand on both public transporters based on 5%, 10% and 20% of the employment force wishing to use the integrated system during the peak hour.

Table 5.4: Demand Analysis of the Integrated System

IS Demand(%)	# of Commuters	# of Trips (# of Taxis)	# of Trains	Headway,min. (Rail)
5	3670	1 (230)	3	20
10	7340	1(300);A(159)	5	12
15	11010	2(300);A(88)	8	7.5
20	14680	3(300);A(18)	10	6

Note: A=Additional trip

As previously mentioned, the maximum number of passengers per train during peak hour depends upon the size of each coach and the number of coaches per train. The headway will depend on the signalling system, speed of train, acceleration and deceleration rates, length of train, station stop time, etc.

Capacity may be increased by increasing the maximum number of passengers per train during the peak hour and/or decreasing the headway. To increase the crush load capacity, the length of the train has to be increased but then the headway shall increase unless the speed is also increased. If we looked at the option of increasing the size of the train sets to 14 coach sets, which is possible, the crush load passenger capacity can be increased to 2350. Table 5.5 shows the impact this will have on the number of trains required during the peak hour based on the projected demands, assuming that the headway remained the same. This would obviously require increasing the speed. It can be seen from Table 5.5 that a 15% demand would require 5 trains, made up of 14 coach train sets, during the peak hour. This can be compared with Table 5.4 where 8 trains, based on the existing 9 coach train sets, would be required for the same demand (15%).

Table 5.5: Demand Analysis of Metro Rail (14 Coach Train-Set)

I.S Demand (%)	Number of Trains (Peak Hour)
5	2
10	4
15	5
20	7

It can also be observed from Table 5.4 and Table 5.5 above that the reduction in the number of trains required during the peak hour is more significant as the demand increases. This highlights the preference of using high capacity modes in order to effectively transport the masses and further reduce the current traffic congestion experienced on most of the roads during the peak periods.

5.5 Conclusion

It must be noted that the above exercise demonstrates the overall or total demand on the proposed system. A pilot study carried out in the Chatsworth area will assist in determining the demand on individual taxi routes. This would help the minibus taxi association to distribute their fleet proportionately. It is also evident that there is considerable potential to increase the capacity of the rail line when compared with the current scheduled service.

CHAPTER 6

DEVELOPMENT OF AN INTEGRATED TRANSPORT SYSTEM

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DEVELOPMENT OF AN INTEGRATED TRANSPORT SYSTEM

6.1 Introduction

The assessment on the current transport situation (Chapter 3) showed that much has to be done in order to increase the utilization of the existing public transport infrastructures and services to realise the objective of 80:20 between public transport and private car usage as targeted in the White Paper on National Transport Policy (Department of Transport, 1996). The commuter survey (Chapter 4) further confirmed the dissatisfaction expressed by car users with regard to the frequent traffic congestion on the Higginson Highway and the levels of dissatisfaction shown by users of different public transport modes on inaccessibility, long waiting times, poor frequency of service and lack of security.

With the increase in car ownership and congestion on the Higginson Highway, new solutions have to be sought to fulfil the needs of passenger transportation. Scarce resources now prompt that better and more appropriate use be made of existing facilities and modes. Increasing the number of buses and minibus taxis during the peaks doesn't solve the problem but in a limited capacity of roads, creates further congestion and thereby reduces the travel speeds and increases the travel time as well as accidents. It is quite obvious that no one measure on its own is likely to provide a solution to urban transport problems. Improvements can be achieved by the integration of the components of the passenger transport system serving the area. These components would then become part of a cohesive whole instead of serving as individual entities.

The integration of public transport modes is a transport policy instrument/model to optimally organise the delivery of public transport services within a region. It is also a pleasing sign to note the strong emphasis on integration in the recently approved White Paper on National Transport Policy. This means that provincial, metropolitan and local governments have to come up with a transport plan for their region and at this stage the structures and expertise have not yet been fully established. Fundamentally, these regions and metropols must decide how they wish to organise transport in a way that will create the optimum social benefit at the least cost. They will very quickly come to grips with issues such as the cost of congestion, energy, accidents, pollution, noise, stress and other related factors.

An attempt has been made in this study to suggest a methodology based on data flow diagrams, to integrate the rail with the minibus taxi services. This technique, because of its simplicity and clarity, is very effective for enhancing communication between users and system designers. Data flow diagrams are easy to read and understand and serve as a strong communication vehicle, especially in dealing with users. Furthermore, users with minimum background and knowledge can readily read, understand and verify models based on data flow diagrams. The technique can also be applied in the formulation of a model for public transport route network planning (integrated approach) which in turn could be applied to the many suburban areas experiencing traffic congestion to the city centres. It is important to understand which mode under which circumstances is best suited for which leg of the total travel demand requirement in a transport corridor. A methodology for restructuring of public transport network to suite local conditions is of extreme importance and necessary. At present, all commuter transporters operate virtually independently with no co-ordination to benefit the commuter. This is a very expensive solution to the needs of commuter transport which the economy cannot support. It is therefore necessary to move towards a co-ordinated solution which caters for the needs of the commuter and can be supported by the economy.

The first important task in this study is to identify the different steps of the integrated planning method. The metro rail system is a major step to achieve a goal of non-congestion, no pollution and reduction in accidents. But this system alone cannot provide the answer since it was estimated that less than five percent of the residents live within 500m from a rail station. Integration of feeder minibus services with metro rail is the best solution for efficiency and optimum output.

6.2 Concept of Integration

System integration is essentially a management technique applied to a group of functions that are currently being administered independently, but are, in fact highly interdependent and could be managed more effectively by being treated as interrelated parts of a single system (Remak, 1979).

A recent report on the role and integration of passenger transport modes which was prepared for Eastern Services Council (Regional Planning) by Del Mistro and Associates (1995) looked at modal integration in terms of co-ordination, research and planning, facilities and operations. With regard to co-ordination, a number of activities that affected passenger transportation and needed to be co-ordinated were highlighted. These included the siting of terminals, subsidies provided by National, Provincial and Local authorities, land use patterns, amount of funds allocated by local authorities for passenger transport projects and permits issued for bus and taxi routes. Research and planning will be enhanced since the database will be comprehensive across the modes and planning can be based on a total perspective rather than on data from individual modes. Furthermore, an integrated data collection and analysis process would be more efficient and cost effective. Where possible, existing facilities, like terminals, should assist in integrating the routes of passenger transport modes, ie. a terminal could serve more than one route and more than one mode. With regard to operation, the important factor was to describe the passenger transport network for an area as a multi-modal network. An integrated passenger transport schedule/timetable was needed and the concept of through ticketing should be introduced.

The author had the opportunity of studying the public transport system within the metropolitan area of Rome, Italy. The observation was conducted in late September 1997 during the period when the Third International Conference on Urban Transport and the Environment for the 21st Century was hosted in Aquasparta, Terni, Italy.

Rome was served by an integrated public transport system operated by the companies Atac-Cotral-FS. The system included a network of metro, bus, tram and metro-type rail services. The city was served by 238 bus routes and 7 tram routes which operated usually from 05:30 to 24:00. Night bus services comprised 27 routes operating from 00:10 to 05:30. These services were recognised by the number followed by the letter "N". The metro comprised two lines: Line A and Line B that linked different areas within the metropolitan area of Rome. Within the central area of Rome, there are six key interchange stations operated by FS and Cotral and integrated with the metro, bus and tram services. The integrated ticket-Metrobus-provided the passenger the freedom of using all the modes of public transport within the metropolitan area of Rome. Tickets had to be bought before the commencement of the journey from any Metro station, authorised vendor (newsagent, tobacconist, cafés) and automatic ticket machines. Travel cards and integrated tickets included annual, monthly, weekly and daily tickets. Commuters also had the option of purchasing a ticket that was valid for 75 minutes, within the metropolitan area of Rome, on all Atac and Cotral services, for one trip on metro line A and B and for one trip on any metro-type FS train (2nd class). Tickets had to be validated on commencement of the journey. Validation machines were located at the rear of buses and trams, at the entry gates of metro stations and within the entrance area of all rail stations. The system adopted certainly improved access control and passenger transfer. For a commuter to choose a route/corridor to reach the desired destination, will prefer minimum time of travel, maximum comfort, minimum fare and proper co-ordination. The options may be either a direct bus/minibus route from origin to destination or using the metro rail system with the aid of feeder services. The former option has the distinct disadvantage of overcrowding and congestion during the peaks since these vehicles also use the Higginson Highway and thus the commuters experience the same frustration as experienced by car users. The latter will only be preferred when minimum effort and time is required during modal transfer, travel time is less and a reasonably high level of comfort is provided. This could only be provided with an integrated route network, a co-ordinated time-table and a unified fare structure.

6.3 Factors for Integration

It is important to address the following factors when applying the concept of an integrated passenger transport system:

6.3.1 Accessibility and Connectivity

The mass transfer of passengers from road based transit to rail based transit will only be possible if the connection between the minibus stops/terminals and rail terminals are properly co-ordinated. It is surprising that though transit planning is vital, this has received little attention and transit decisions are taken mostly on intuitive judgement and adhocism without any systematic transit planning study. Generally, the commuter was found to be insensitive to the cost of the travel but more with travel time. Assessment on the current transport situation in the survey area also revealed that there was not adequate coverage of the total area and overlapping of the routes was very common. Commuter details that could be fed into a network system will assist in determining the routes that need to be added to each zone in order to meet the accessibility criteria.

6.3.2 Unified Fare System

A key factor in the demand for public transport is the level of fares charged and the method by which the charge is made. The ultimate form of fare integration is the situation in which the fare is paid once, regardless of vehicle and mode changes. A single ticket system is necessary to reach a passenger from origin to destination. This will certainly avoid the wastage of time in taking separate tickets for travel to use both the modes. The fare scales may be categorised as: graduated by distance, zonal, flat or timed based. Decisions on transport subsidy will also be more effective and easier to implement in an integrated system/unified fare system. Also, issues such as discounted fares for weekly/monthly commuters, scholars, senior citizens, etc. can also be addressed better in an integrated system. Reduced fares may also be provided for shoppers during off peak periods, tourists, families or the disabled. However, it should be noted that any fare structure must provide the revenue necessary to meet whatever financial targets are set and it should be comprehensible to the user. Furthermore, it should facilitate smooth operations, avoiding unnecessary delays and minimising opportunities for fraud and evasion. Finally, it should be sufficiently flexible to permit new marketing strategies to be evolved.

6.3.3 Integration Information

A common minibus-metro rail guide and a total information service should be available to the commuter. The passenger transport options should also be brought to the attention of private vehicle users. The new services will have to be marketed and widely advertised with the intention of attracting new ridership in addition to providing existing users with information. The guide should include information on the scheduled routes, timetable and fares.

6.3.4 Physical Integration

This includes the provision of better transfer facilities as well as the siting of minibus terminals near the rail stations. These will provide for easy access from minibus to rail and vice-versa. The provision of park-and-ride/kiss-and-ride facilities at the station should also be included in order to attract private car users. It is extremely important that strict security be provided for private vehicles at the stations in order to increase new ridership.

6.3.5 Network Integration

An examination of the present practices reveal that most of the approaches for mass transport network generation and evaluation are still orientated towards single mode planning. Hence, whenever a new mode is introduced it has not been possible to visualise and analyse the effect of any change on the whole system because of the complex inter-relationships among them. An integrated approach to transit network planning which better fits into the overall urban transportation planning process is essential. It has therefore become necessary to restructure existing transit routes in order to reduce wasteful duplication of services between bus, minibus and rail. The passenger transport network for an area needs to be designed as a multi-modal network where the arrival of say minibuses at an interchange point (eg. rail station) needs to be co-ordinated with the departure of the vehicles with which interchanges are occurring (ie. rail). As already highlighted in 6.3.2 above, an integrated passenger transport schedule/timetable is essential.

6.4 Integrated Transport System Development

With regard to the study area, it was found that the minibus taxis association operated on the inner circle route (greater Chatsworth area) and only recently allocated a small percentage of it's fleet to the Durban CBD route which resulted in conflict with the bus association. Interviews with the Chatsworth Minibus Association with regard to the formation of a partnership with metro rail in providing a feeder service to the stations proved promising and positive. The South African Rail Commuter Corporation fully supports an integrated public transport system. It was therefore decided to look closely at this option and attempt to formulate an integrated system between the taxi association and metro rail. A methodology has been presented for developing a computer simulation model for the operational analysis of minibus-rail integration.

The primary aim is to try and set up an integrated transport system in the study area with the intention of capturing commuters that will eventually become "committed" to the system - similar to payments made towards the use of telephones, electricity and water. Integrated fares should be made more attractive (greater discount) for the purchase of a monthly, semester or even an annual transport card. The main frame should be set up at the Chatsworth Centre (shopping complex) where the bulk of the residents from the area make their purchases and account payments. Terminals should be located at the five railway stations and perhaps at some of the post office depots in the area, with a view of introducing automatic ticket dispensers at a later stage. Card readers/validation machines will have to be installed on minibus taxis and at the entrance to the station platforms. Commuters will be required to validate their cards at the commencement of the trip. During the journey, ticket inspectors, that could also be employed as security personnel, will conduct random checks to ensure that tickets are valid. Strict fines will have to be imposed in order to prevent fare evasion.

Through a structured analysis technique called data flow diagrams (DFD), a graphical representation of data processes throughout the organisation is presented. Before attempting to develop a data flow diagram for an integrated public transport system, it is important to understand the concept behind this approach. Data flow diagrams indicate the flow and transformation of data within a system. They serve as a strong communication vehicle and this approach emphasises the logic underlying the system. DFD hide timing and control features of the system, thus allowing the project team to understand the system better, as well as, discover redundancies and inaccuracies in the way data is processed. By using combinations of only four symbols, one can create a pictorial depiction of processes that will eventually provide solid system documentation.

Advantages of the data flow approach include the following:

.Freedom from committing to the technical implementation of the system too early.
.It serves as a useful exercise for systems analyst, enabling them to better understand the interrelatedness of the system and its subsystems.
.Communicating current system knowledge to users through DFD.
.Detecting and correcting errors and design flaws at the early stages of the systems development life cycle. It is therefore far less costly than in the latter phases of programming, testing and implementation.

6.4.1 Components of a Data Flow Diagram

A data flow diagram consists of four basic components, namely external entities, processes, data flows and data stores. The characteristics and use of each of these components is reviewed below:

6.4.1.1 External Entities

They are entities which are outside the system but which communicate with the system. Usually, the people that communicate with the system or the documents are represented as external entities. In this case the typical external entities will be the commuters, minibus taxi association and metro rail and accounts. Although "accounts" is within the system, it is outside the terms of reference to the solution of this problem. They can send data to or receive data from the system. A rectangle indicates any entity external to the system being modelled.

6.4.1.2 Processes

Processes always denote a change in or transformation of data. They represent work being performed within the system. Processes must also be given a unique identifying number indicating the level of the diagram. Processes should be cohesive and have a few inputs and outputs as possible. An example of a process will be to update the route schedule for minibus taxis. Bubbles or circles are used to indicate those points within the system at which incoming data flows are processed or transformed into outgoing data flows.

6.4.1.3 Data Flows

In a DFD, the arrow shows movement of data from one point to another, with the head of the arrow pointing towards the data's destination. Data flows occurring simultaneously can be depicted doing just that through the use of parallel arrows. In simple terms, data flows describe data that flows through the system. Data flows should include the minimum essential data needed by the process that receives the data flow. All data flows should begin and/or end at a process, because data flows either initiate a process or result from a process.

6.4.1.4 Data Stores

They are passive stores of information. In DFD, the type of physical storage (for example, tape, diskette, etc.) is not specified. At this point, the data store symbol is simply showing a depository for data that allows addition and retrieval of data. Data stores should describe "things" about which the business wants to store data. A data flow from a data store to a process means that the process uses the data while a data flow to a data store means that the process updates (adds, deletes or changes) the data store. Open rectangles are used to identify temporary holding points for collection of data. Data stores are sometimes duplicated to avoid crossing of data flows. These duplicates are identified with a vertical line. TRIP SCHEDULE is a typical data store used in this example.

6.4.2 Developing the Data Flow Diagram

To begin a data flow diagram, the organisation's system narrative is collapsed into a list with the four categories of external entity, data flow, process and data store. This list in turn helps determine the boundaries of the system to be described. The first stem is to draw a context diagram, followed by the top level diagram and then the detail level data flow diagram. These stages are discussed very briefly below:

6.4.2.1 Context Diagram

The context diagram gives an overview of the systems interaction with its environment. The environment consists of the external entities and data stores that are considered to be outside the system. This diagram shows all the external entities that interact with the system and the data flows between these external entities and the system. The context diagram is the highest level in a data flow diagram and contains only one process, representing the entire system. A typical context diagram for an integrated public transport system as developed in this study involving metro rail and minibus taxis is reflected in Figure 6.1. This is the most general diagram - really a bird's eye view of data movement in the system and the broadest possible conceptualization of the system. The external entities ie. minibus taxi association, metro rail, commuter and accounts are shown on this diagram and the major data flows to and from the external entities are also reflected. The context diagram contains only one process (Integrated Transport System) that represents the entire system. Typical data flow from the external entity labelled COMMUTER to the Integrated Transport System include: "application details" and "payment". Similarly, data flow to the external entity COMMUTER from the Integrated Transport System include "amount due" and the "integrated time-table and ticket".

6.4.2.2 Top-Level Data Flow Diagram (Diagram 0)

This diagram gives a overview of the main functions of the system and the flow of data through the system. Each main function is represented by only one process. Diagram 0 is an explosion of the context diagram and may include up to 11 processes. This diagram still contains all the same inputs and outputs as the context diagram. The only difference is that the single central bubble in the context diagram has been partitioned or decomposed into a series of components. The major data stores of the system (Route Details/Count, Trip Schedule, Fleet, Integrated Time-Table) and all external entities (Commuter, Metro Rail, Taxi Association, Accounts) are included on diagram 0. Since a data flow diagram is two dimensional (rather than linear), it is possible to start at any point and work forward or backward through the diagram. The top-level DFD for the system is shown in Figure 6.2. The COMMUTER (external entity) requests to use the system indicating his/her origin and destination as part of the *application details* required to process the application (Process 1). The physical address as part of *commuter details* will assist in identifying the route node closest to the commuter as reflected in Process 2. Route details pertaining to all commuter requests are stored in a database called "ROUTE DETAILS/COUNT".The direction of arrows relating to data stores is important since data flow from a data store to a process means that the process uses the data ie. a "read" is assumed. On the other hand, a data flow to a data store means that the process updates (adds, deletes or changes records) the data store. Based on a radius system for the determination of fares, the amount due is received from the commuter. All payments are deposited in a central accounting system called ACCOUNTS (external entity) via the *handle payments* process (Process 3). The TAXI ASSOCIATION (external entity) supplies a transport schedule based on the designated routes and nodes through the various units in the area to one of the five rail stations closest to that particular unit. The system allows for updating route schedule (Process 4) depending on commuter demand. Information pertaining to route details are placed in the data store TRIP SCHEDULE. The schedule also takes into account the available fleet of the association in determining the frequency of the service to be provided. Once again, depending on passenger demand, the vehicle details may be updated (Process 5) with FLEET being assigned as the data store. *Fleet details* are utilized in updating the frequency of service to be provided (Process 6). *Vehicle frequency* details are also stored in TRIP SCHEDULE. The taxi schedule details (route schedule and vehicle frequency) are used to generate a transport schedule (Process 7) for the taxi industry. The taxi transport schedule is then combined with the existing time-table for METRO RAIL (external entity) to *generate a new integrated time-table* (Process 8), copies of which are directed to both the public transporters. It is obvious that adjustments would have to be made from time to time to either or both of the public transporters' time-table depending on the demand for the integrated transport system (ITS). The demand analysis of the system was discussed in Chapter 5. All commuters that have paid (via the application process) to use the system, receive a copy of the integrated time-table together with his/her computerized ticket/travel card.

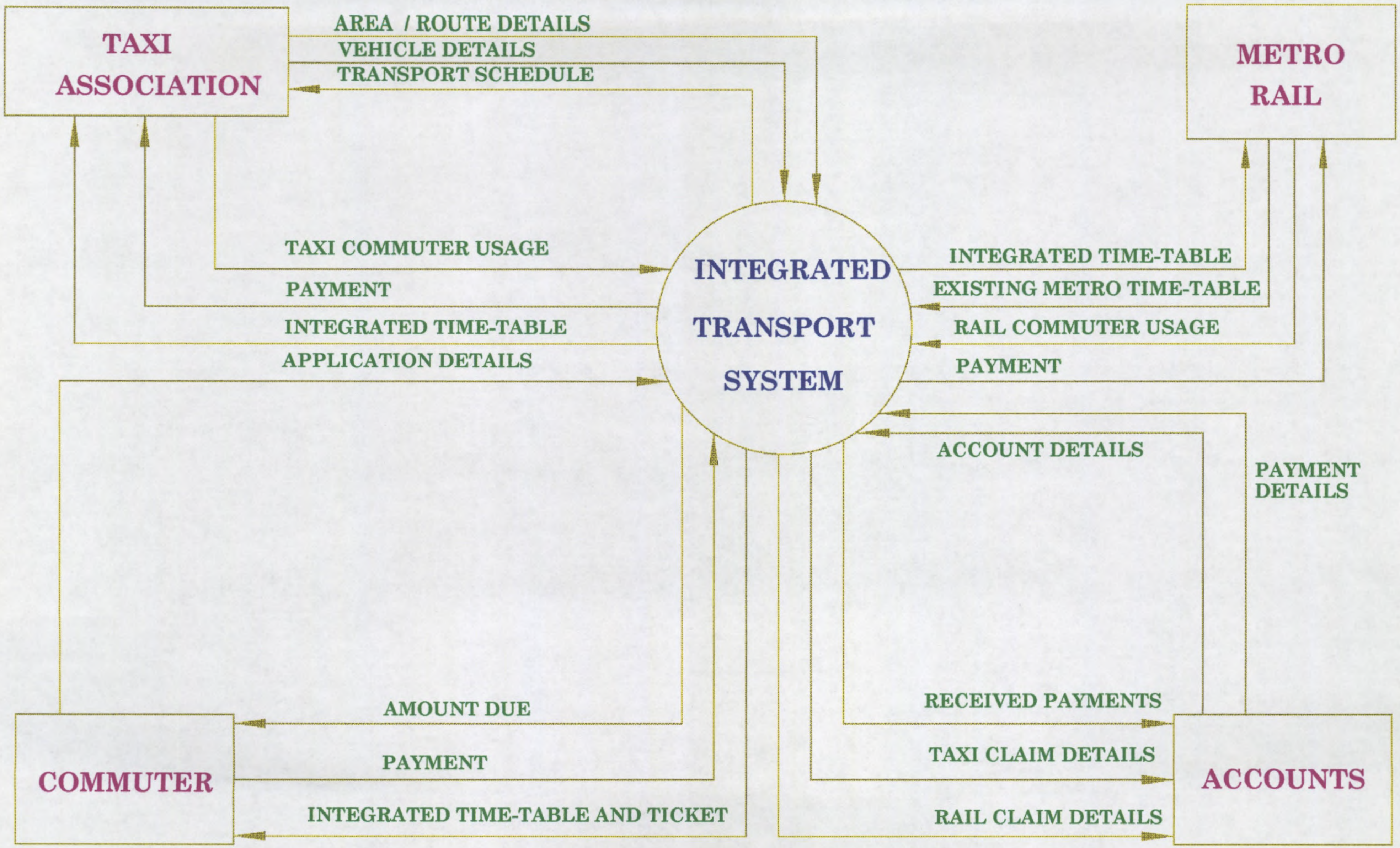

FIGURE 6.1 : CONTEXT DIAGRAM FOR THE INTERATED TRANSPORT SYSTEM

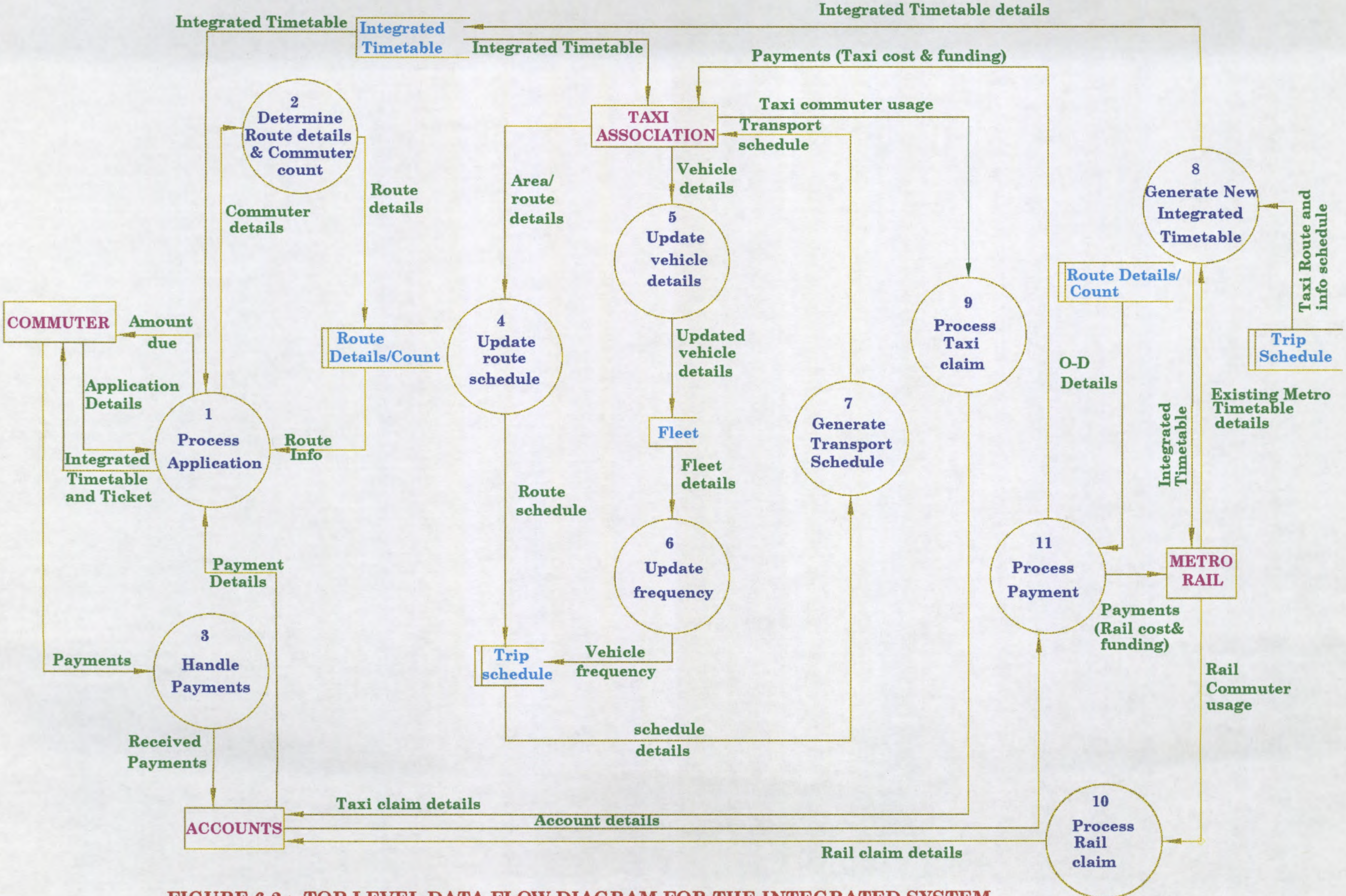

FIGURE 6.2 : TOP-LEVEL DATA FLOW DIAGRAM FOR THE INTEGRATED SYSTEM

Depending on the taxi commuter usage, the amount due to the Taxi Association is determined (Process 9) and the taxi claim details are forwarded to ACCOUNTS (external entity). Similarly, based on the rail commuter usage, the amount due to Metro Rail is calculated (Process 10) and also forwarded to ACCOUNTS. Account details are verified against commuter details initially placed in the data store ROUTE DETAILS/COUNT. The final payment (Process 11) is based on the assumption that some funding/subsidy is made available by Government in order to keep the integrated fare as low as possible thus attempting to make the system more attractive to commuters and further assisting with the integrated system gaining momentum.

6.4.2.3 The Detailed Level Data Flow Diagram (Child Diagram)

Each process on Diagram 0 may in turn be exploded to create a more detailed child diagram. However, it should be noted that processes may or may not be exploded, depending on their level of complexity. It is always advisable to use original, unexploded data flow diagrams (as in figure 6.2) in the early stage when ascertaining information requirement. Overly exploded diagrams may not be helpful to the users since changes will need to be incorporated after getting users input. The process on the top level diagram that is exploded is called the parent process, and the diagram that results is called the child diagram. Data flow balancing is off course necessary where flows are carried over from a higher level to a lower level. On this level, data stores which are local to a process can be shown for the first time. All data flow in or out of the parent process must be shown flowing in or out of the child diagram. The numbering of the child diagram is derived from the numbering of the parent process in the top-level data flow diagram (diagram 0).

For the purpose of illustration, two examples of the detail level data flow diagrams are shown in Figure 6.3 and Figure 6.4.

Figure 6.3 reflects the application process where the commuter requests to use the facility indicating his origin and destination (Process 1.1). This information, obtained from all commuters, is stored in a database for calculating the amount due by the commuter as well as for the purpose of audit/payment to the taxi association and metro rail. In determining the amount due by the commuter, the following two approaches may be considered. Firstly, the radius may be determined from the route node closest to the locality of the commuter to the destination rail station (Process 1.2). The cost factor based on the radius system may then be applied to determine the amount payable (Process 1.3). The second approach, which is certainly easier to implement, is to charge a fixed taxi fare from the various units to the nearest rail station. This procedure/fare system is presently adopted by the taxi association in the survey area when transporting passengers on the inner circle route from the various units/sections to the main shopping complex area. This approach will further assist with the formulation, implementation, monitoring and control of the system. The development of a computer simulation model with regard to the payment aspect will also be easier to programme. The radius system may then be used to determine the rail cost based on the origin and destination stations (Process 1.2). This cost added to the fixed taxi fare will yield the total amount due by the commuter (Process 1.3). On payment of the amount due, the commuter is given an integrated timetable together with the ticket/travel card. The system could be designed to check for outstanding payments, as in the example and as reflected in Process 1.4.

Figure 6.4 reflects the payment procedure for metro rail and the minibus taxi association. Both the public transporters operators will be able to check/confirm commuter usage from validation machines/card readers installed on minibuses and at the entrance to stations. For audit purposes, these details can be verified with the information stored in the data base "ROUTE DETAILS/COUNT" during

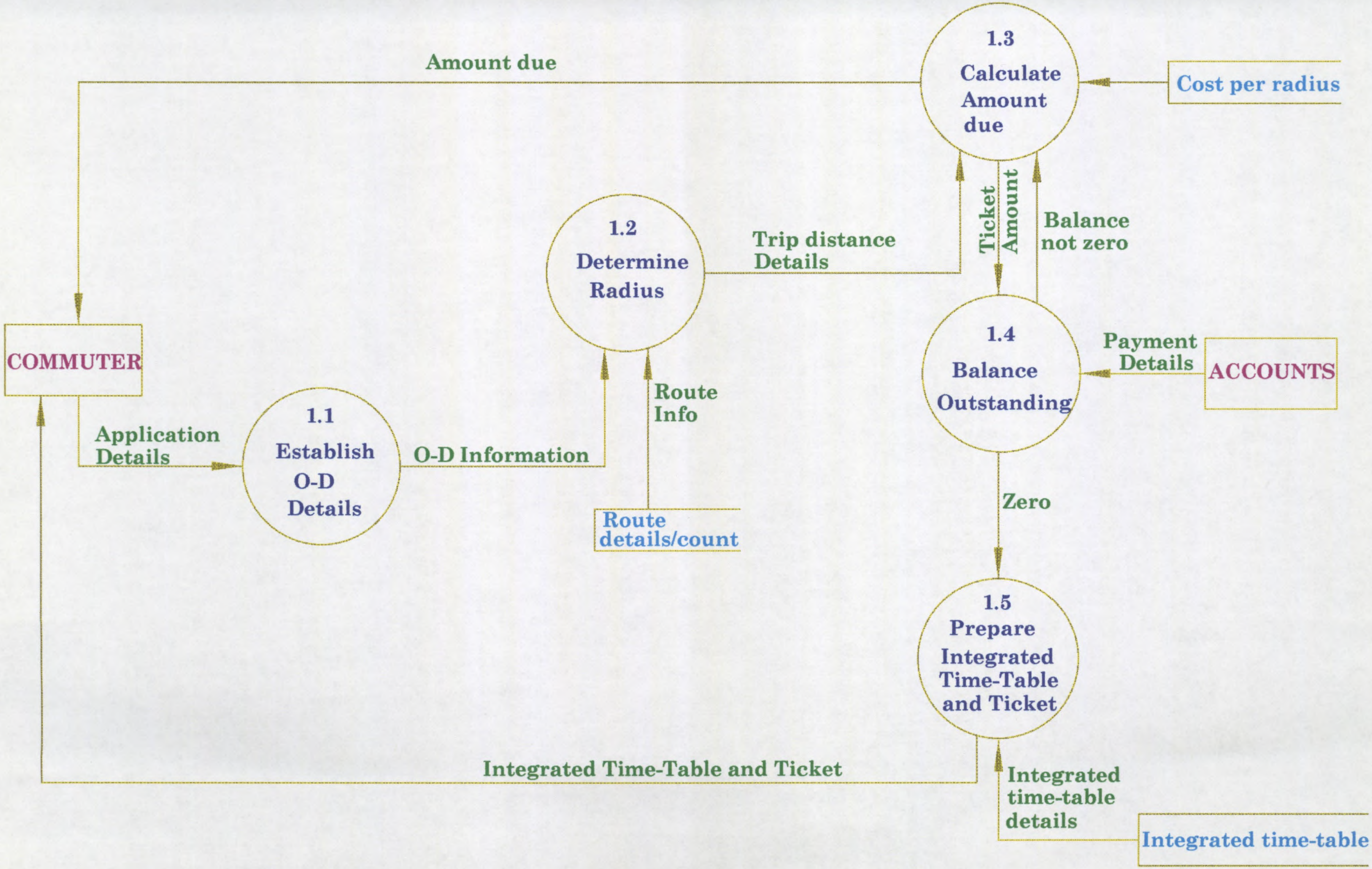

FIGURE 6.3 : DETAILED LEVEL DATA FLOW DIAGRAM : APPLICATION PROCESS

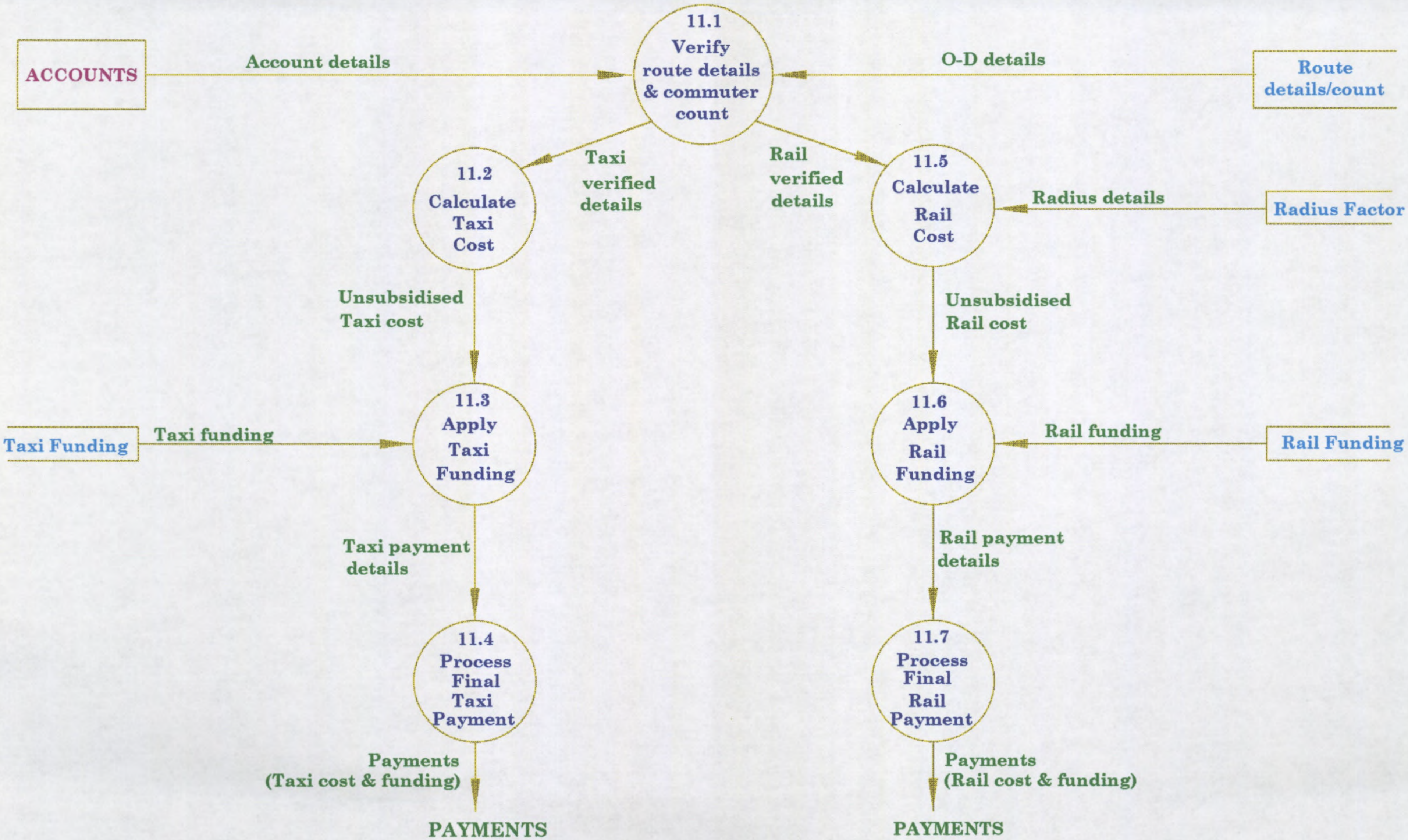

FIGURE 6.4 : DETAILED LEVEL DATA FLOW DIAGRAM : PAYMENT PROCESS

the application stage (Process 11.1). The verification process could also identify other factors/problems such as fare evasion. Based on a fixed fare system and a radius system for taxi and rail respectively, the total costs are calculated (Processes 11.2 and 11.5). Assuming that some assistance is initially offered by the Government in order to keep commuter fares to a minimum and at the same time supporting public transport and the integration system, the final payments are processed. This is obtained by applying the Government subsidy to the actual costs calculated for taxi and rail (Processes 11.3 and 11.6). The final taxi payment takes into account taxi cost and Government subsidy (Process 11.4) and the final rail payment is based on the rail cost and Government subsidy for rail (Process 11.7).

6.5 Conclusion

An integration technique has been developed in this study based on data flow diagrams in an attempt to integrate the rail with the minibus taxi services. It should be apparent that as powerful as data flow diagrams are, they require further, supporting documents that will define the contents of the data store and define the processing that takes place in bubbles that have not been partitioned. DFD are useful throughout the analysis and design process. They can help provide an overview of data movement through the system, lending a visual perspective unavailable in narrative data. If data flow diagrams are used as a tool to solicit more specific information requirements from users, they should not be highly exploded in any medium before users have had a chance to work through them with the systems analyst. Changes may need to be incorporated after getting additional input from users.

CHAPTER 7

DEVELOPMENT OF THE PROTOTYPE

CHAPTER 7

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7.1 Overview

An integrated technique was developed in this study (Chapter 6) based on data flow diagrams in an attempt to integrate the rail with the minibus taxi services. The model developed provided the user with an overview of data movement through the system, adopting a visual perspective that was unavailable in narrative data. However, there was scope to look at a more practical solution by expanding on the integration technique suggested.

Considering the human and financial resources available and the constraints on time, it was not possible to go for a full scale model. It was therefore decided to develop a prototype model following the methodology based on the data flow diagrams in Chapter 6. Prototyping can be classified as a modelling approach which emphasises the creation of abstract description of a software system in order to answer questions about the system. The emphasis is on the determination of the feasibility of a proposed solution before investing in the large scale development of the target system ie. the intention is to go a step closer to the pilot program by developing a prototype model program. The prototype system fulfils the most important requirements of the user in an undetailed way, in a relatively short time by using tools such as screen generators. The user will be able to determine from the input and output screens as to whether his or her needs are being met by the software thus avoiding expensive programming. It should be highlighted that even if the resources were available to build the entire system, problems may arise if refinements or changes are needed. The cost implications at this stage could be astronomical. By building a working model of the system (prototype) as initially envisioned by the user, the user could work with this model, suggest changes and have these changes quickly incorporated into a revised working model. It should be further noted that the prototype is a functioning system or subsystem doing real processing with which the user can interact.

7.2 Prototyping as a Solution

One way of minimising any kinds of risk is to construct a prototype which can then be tested to determine whether it is worthwhile to develop the actual system. Prototyping can help when the user is unable to visualize how the proposed system will work. It triggers user reaction and therefore serves to introduce an element of communication and feedback. The purpose of the prototype is to enable the client and the developers to agree as quickly as possible on what the product is required to do. What is of importance is that this experimentation will help achieve user friendliness, a vital objective of all software products. The visibility of screen flow which is an essential feature of a prototype allows the user to follow a function which makes the checking of function proposals so much easier. It further encourages earlier appreciation of a proposed system and also makes it easier to see the consequences of a proposed change. The first step in the prototyping process model is to build a prototype and let the client and future users interact and experiment with it. Once the client is satisfied that the prototype does most of what is required, the developers can draw up the specification document knowing the clients real needs.

The development of a prototype with input/output screens to final specification will include:

1. The analysis of existing data flow diagrams in relation to screens.
2. Structuring of input/output screens.
3. Programming of input/output screens.
4. Implementation and testing of screens using set test data.

NOTE: The programming of getting to an output screen from an input screen is not present in the prototype.

7.3 Tools and Procedure used in the Development of the Prototype

It can be summarised from the information previously covered that the main objectives of the prototype include:

. Minimizing risks involved in the development of the full system.

. Assisting the user in visualizing how the proposed system will work.

. Providing the means of building a trial version of a software system in a fast, economical and effective way.

. Determining whether it is worthwhile to develop the actual system.

. Determining whether the needs of the user are met by the software thus avoiding expensive programming.

The data flow diagrams presented in the previous chapter were used in the development of the prototype. However it should be noted that the development of the prototype required the explosion of some of the bubbles/processes. The development of the complete system would require all processes to be exploded.

In the prototype, the conventional punch card ticket was illustrated as an output that would be used for the control of the integrated system. It was decided to go for a single or common ticket system where the fare is paid once, regardless of vehicle and mode changes. In this case, a common ticket was proposed in order to gain access to the minibus taxi and rail systems. This will avoid the wastage of time in taking separate tickets for travel to use both the modes. The punch card ticket will have the necessary information such as the taxi boarding point, origin and destination rail stations and whether the ticket is valid for a single, return or weekly trip. Provision is also made on the ticket for both public transporters to verify usage by punching the ticket in the appropriate grid or space. Screen 6 in this chapter gives a typical example of a single ticket with all the relevant information.

Other options with regard to the type/format of the ticket include:

1. A simple plastic card that is valid for a certain period as specified/reflected on the card. Commuters are entitled to any number of trips for the valid date range. The assumption is that most commuters would use the ticket for an average of ten trips per week. This system would require constant monitoring and could lead to abuse by the operators and/or the commuters.

2. Smart Cards: These are similar to telephone cards incorporating the latest technology and has a built-in chip. Each time the Smart Card is swiped at a taxi or train terminal/entrance, the available amount on the card is reduced. The control of fraud and system security are inherent in the design of the smart card system. This option would require the installation of smart card readers, a highly versatile electronic ticketing/validation system, which can be specifically designed for use on minibuses and metro systems. It is designed to reduce the need for cash handling and speed-up passenger movement. The smart card facility could also allow for the provision of a "black list" for lost or stolen cards and cards could also be retained under software control. This system, although

more expensive, will offer improved efficiency and a friendly and beneficial service to commuters without detracting from operational efficiency and management planning.

As previously suggested, the server would be based at a central position (Chatsworth Centre) with terminals located at each of the five stations in the area. The server and terminals will be connected by means of a dial up WAN (Wide Area Network). Every evening, say at 20H00, the terminals would download the daily data to the server in order to consolidate the number of tickets sold.

With the smart card option, each station would require card readers installed at access points. Commuters would be required to swipe his/her card, which would increment a counter, update the swipe card, activate the turnstile and allow commuters access on to the platform. Each taxi would also be fitted with a card reader that increments a counter and updates the smart card.

7.4 Development of the Prototype

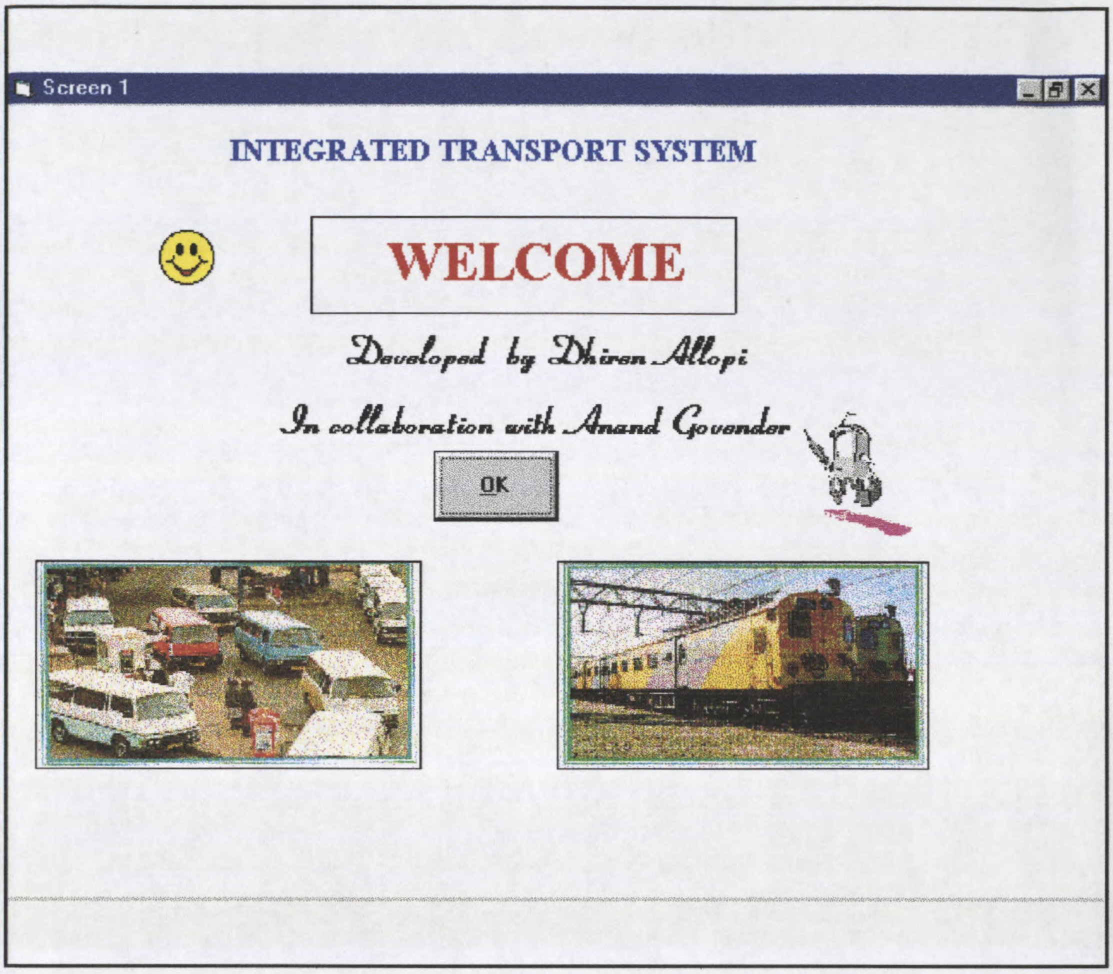
The prototype was developed around the option of using the integrated public transport system (minibus taxi and rail) since this was the main purpose or focus of the exercise. A host of ticket options ranging from a single to a yearly ticket were included in the input screen. For the purpose of demonstration, the first three options were included in the prototype (single, return and weekly ticket). The default was set on Bayview station as the origin/boarding station. The destination stations were set on Merebank, Clairwood and Durban for the single, return and weekly ticket options respectively. With regard to the taxi route, three nodes on Pelican Drive (Pelican/Turnstone, Pelican/Skylark, Pelican/Liberty) were considered as typical stops leading to Bayview Station. The system was designed on the assumption that both the taxis and trains strictly follow the time schedule.*However, a buffer of 10 minutes was allowed between the arrival time of the taxis at the station and the departure time of the train. Adjustments would obviously have to be made from time to time to cater for the demand on various routes. A commuter wishing to use the system indicates his/her choice of ticket (single, return, weekly), origin and destination of travel.

The cost of the ticket and the necessary travel information such as taxi node/stop, taxi and train departure times are given to the commuter. Upon payment, a printout of the ticket is handed to the passenger. The prototype also allows for a printout of the complete schedule reflecting the integrated timetable, if the commuter so requests for a detail schedule. It is anticipated that a detail schedule will be requested for at the initial stage or commencement of the integrated system until such time commuters become familiar with the timetable. A step-by-step procedure on how to use the prototype is discussed in the next section. A copy of the program on disk is provided which is placed in an envelope that is attached to the inside of the back cover of the thesis.

7.5 Procedure for the use of the Prototype

7.5.1 Using Windows'95 click the **start** button to RUN the programme from the floppy drive. The executable file is called **Trport.exe.**

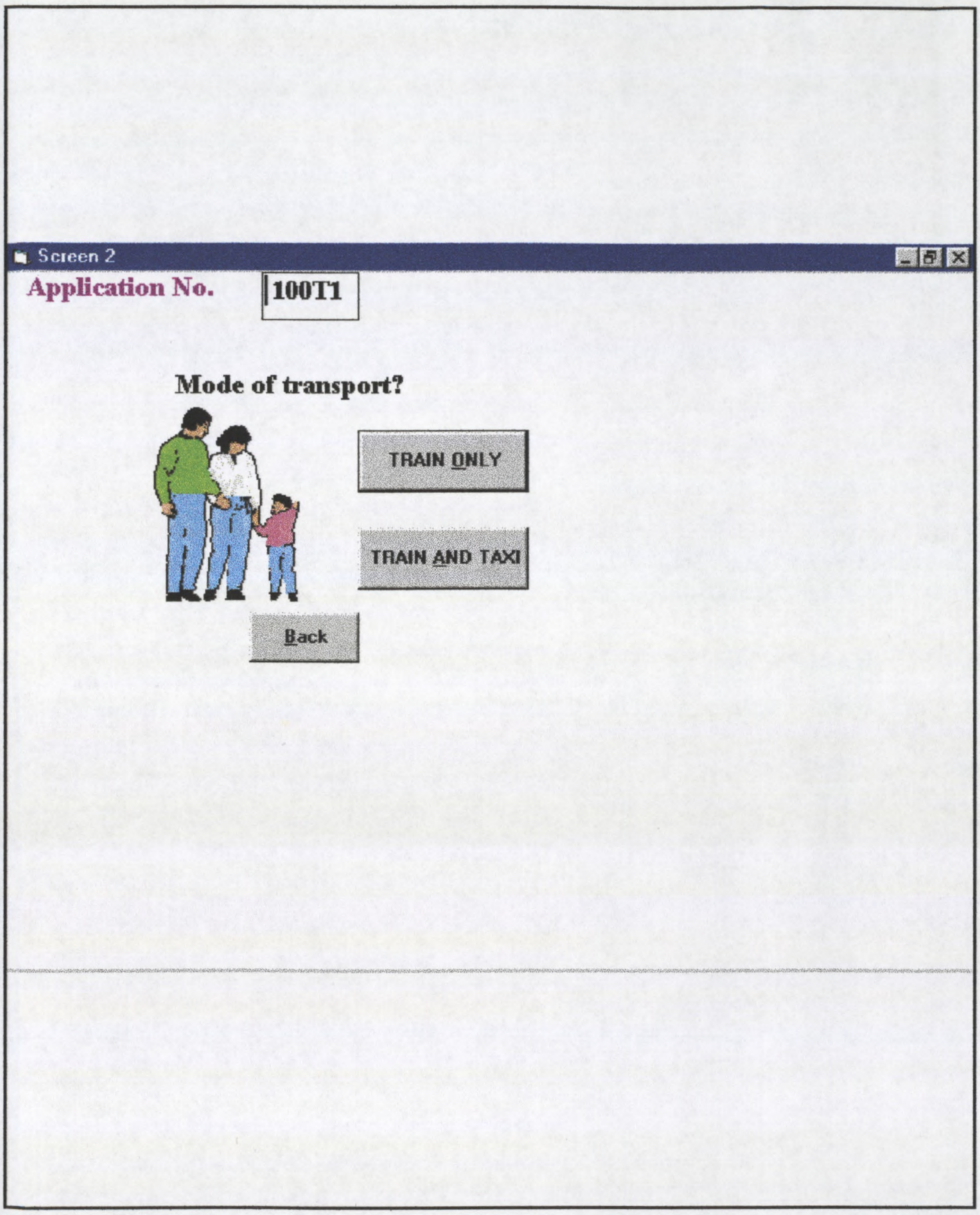
7.5.2 Screen 1, the introduction to the integrated system, appears.



SCREEN 1: Introduction to the Integrated System

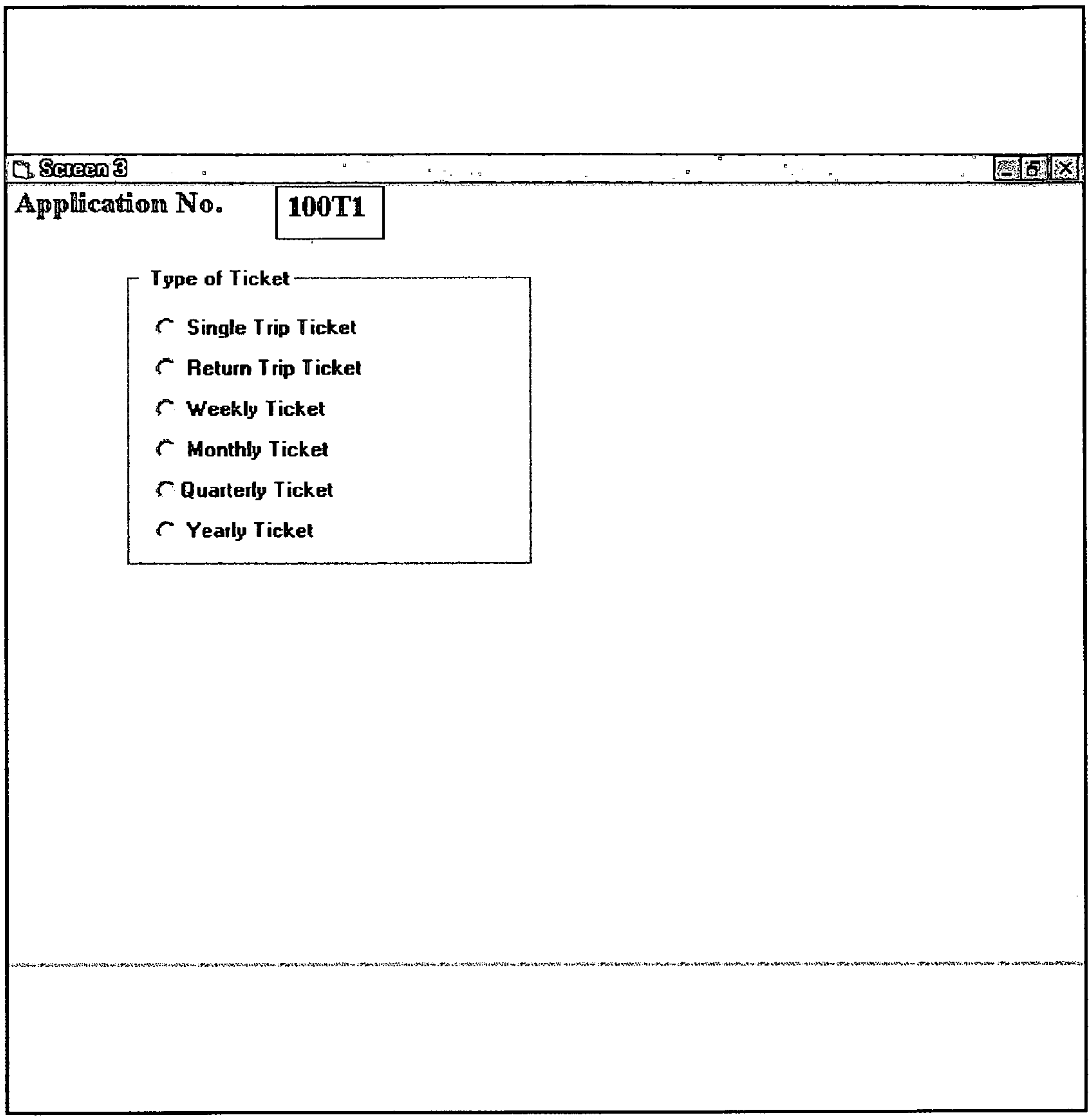
Click **OK** to continue.

7.5.3 Screen 2 which offers the modal choice appears. Since the main emphasis of this project was to look at the integration between the taxi service and metro rail, the prototype was developed around this option.



SCREEN 2: Modal Choice

7.5.4 Click on **Train and Taxi .** Screen 3 appears



SCREEN 3: Ticket Option

For the purpose of demonstration, as previously indicated, the first three options may be chosen, ie.

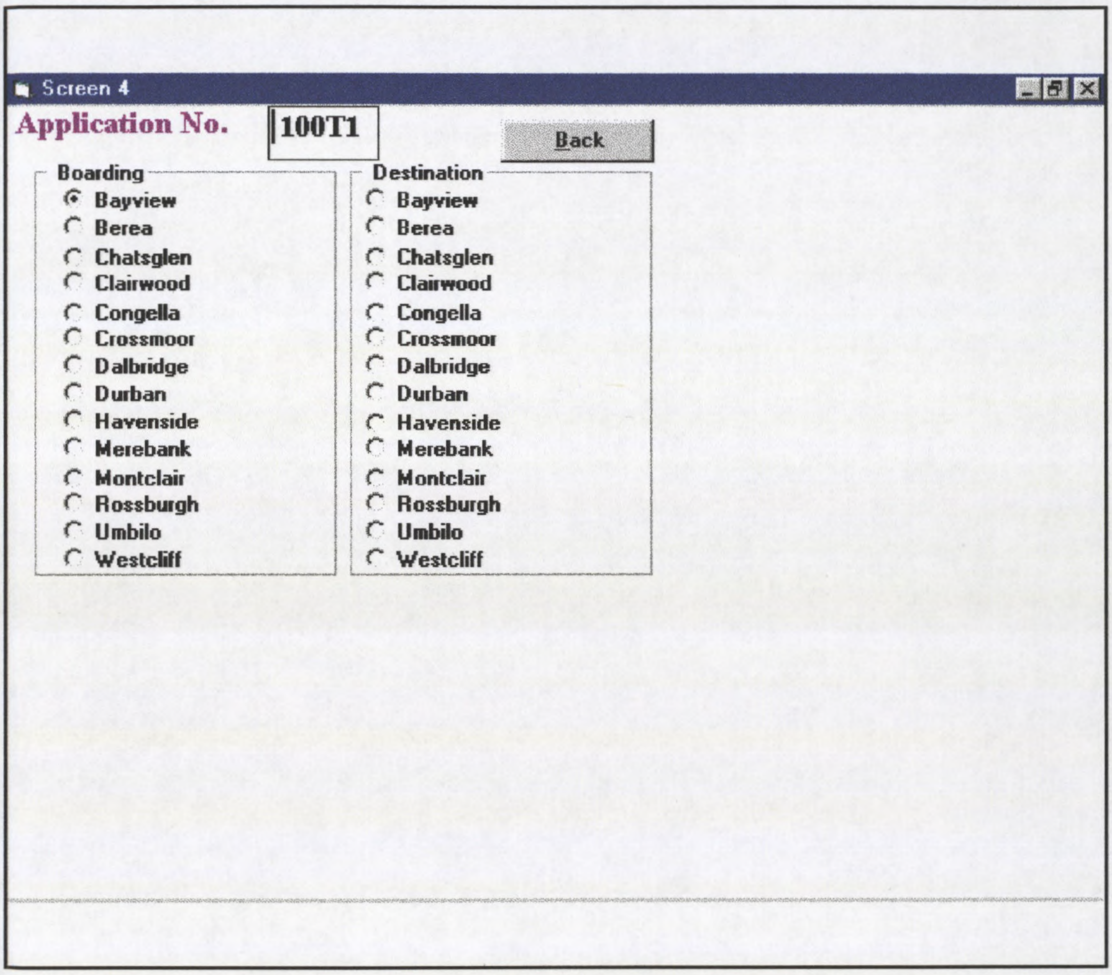
7.5.4.1 Single ticket

7.5.4.2 Return ticket

7.5.4.3 Weekly ticket

To activate the "single ticket" option, click on **Single Ticket**.

7.5.5 The origin/boarding and destination stations are reflected on screen 4.

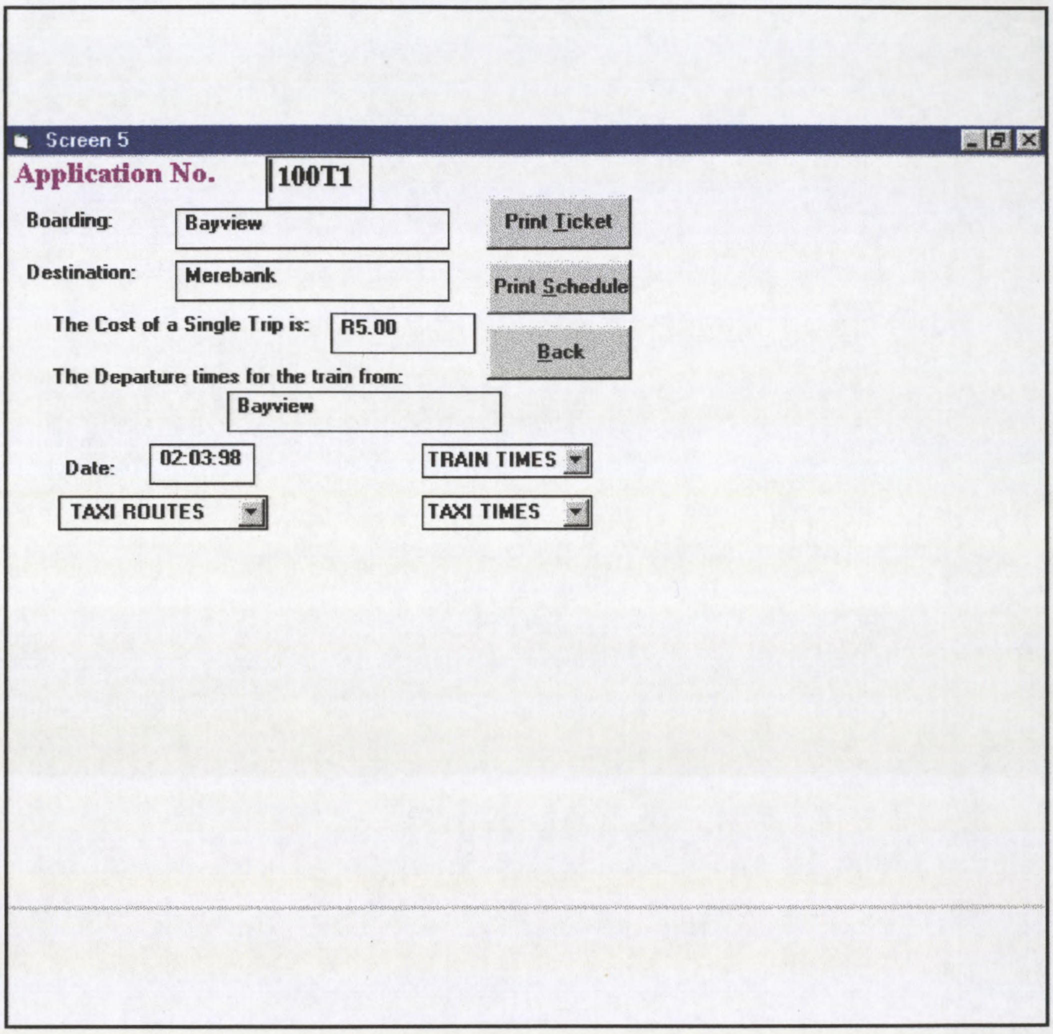


SCREEN 4: Boarding and Destination Option

The boarding option will remain constant ie. **Bayview.** The single ticket option has been set on **Merebank** as the destination station. Click on **Merebank.**

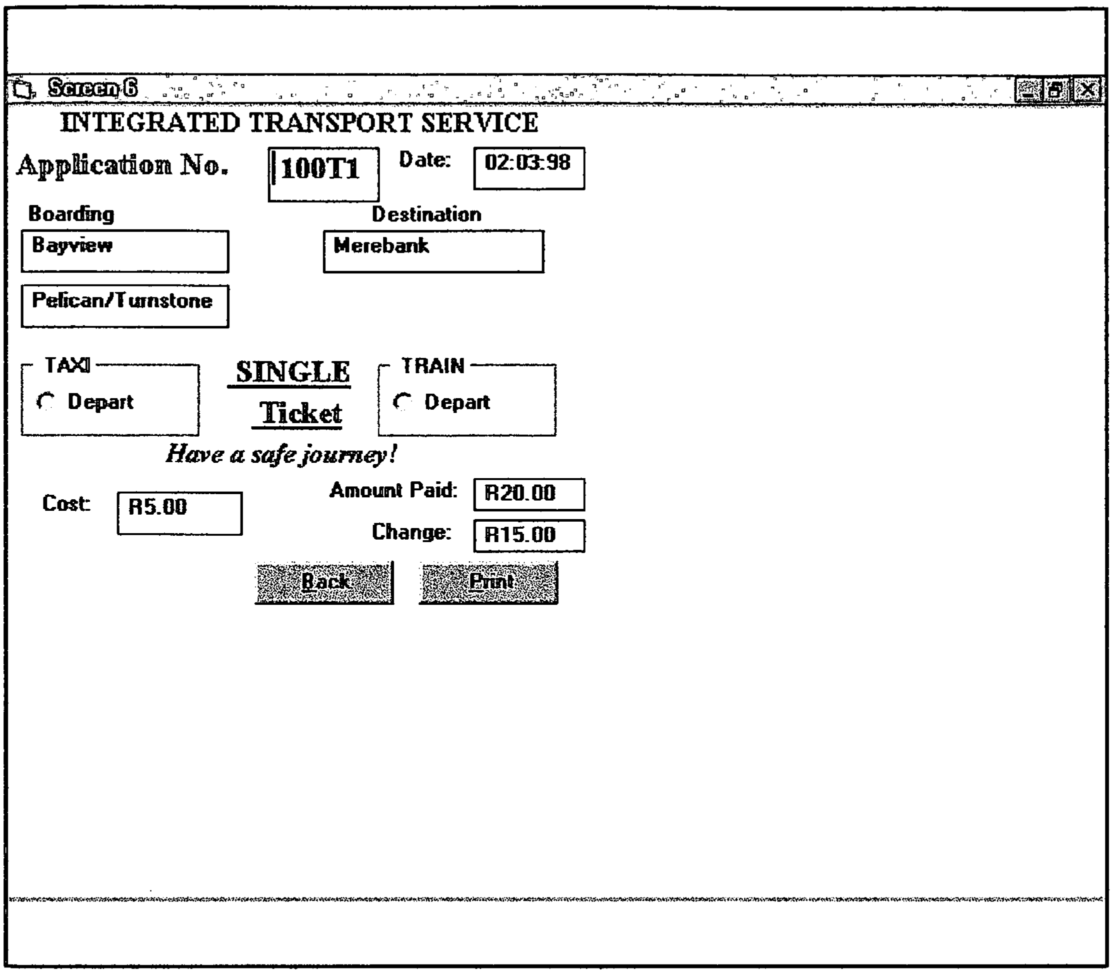
7.5.6 Screen 5 appears with all the relevant information which includes the taxi stops on route to Bayview station and the departure times from each route node.

The train times and cost of the ticket are also reflected.



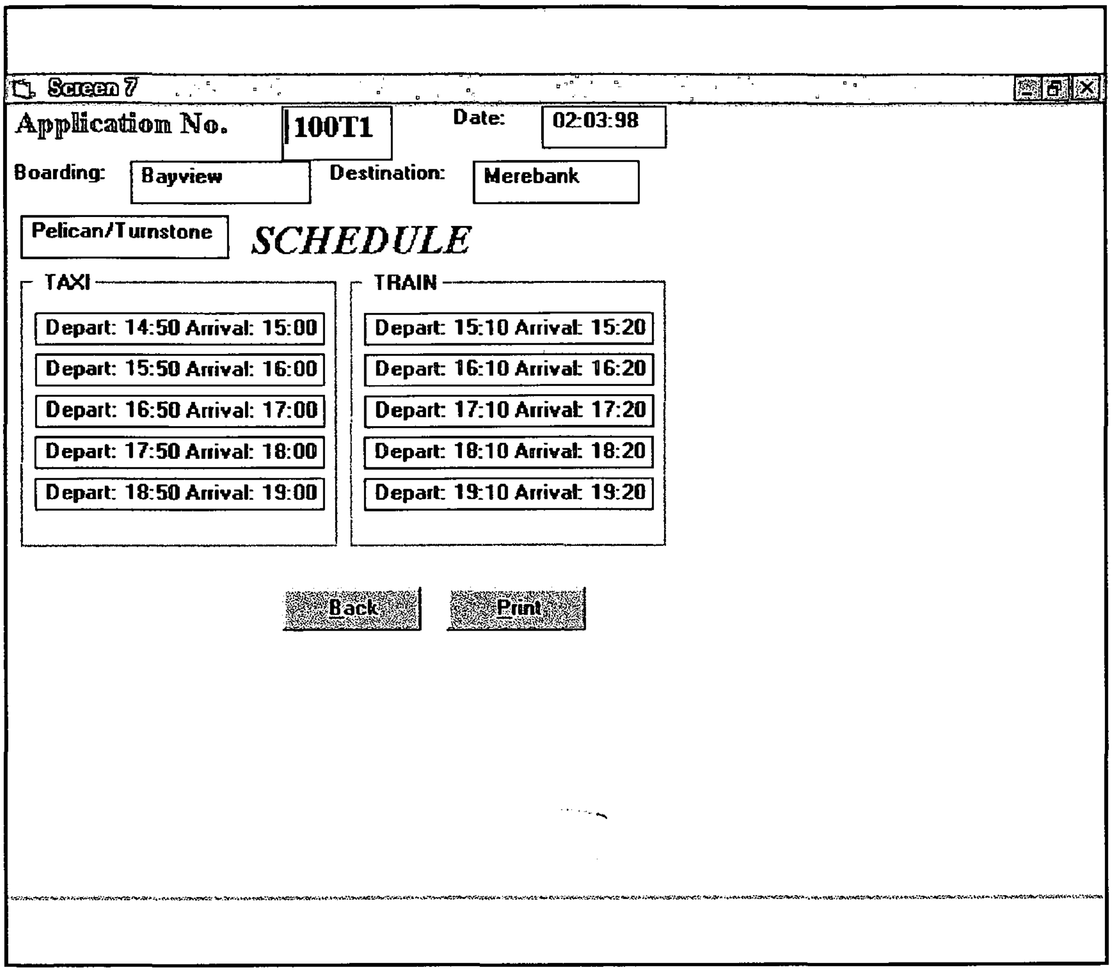
<u>SCREEN 5: Travel Information : Single Ticket</u>

7.5.7 Options exist on screen 5 to print the ticket and/or print the schedule. Click on **<u>Print Ticket</u>**. Screen 6 displays the soft copy of a single ticket reflecting the boarding and destination stations, the departure time for the taxi and train as well as the cost of the ticket, amount paid by the commuter and change (if any) due to the commuter.



SCREEN 6: Single Ticket

7.5.8 When Print Schedule is selected, the integrated time-table for the taxi association and metro rail appears as shown on screen 7.

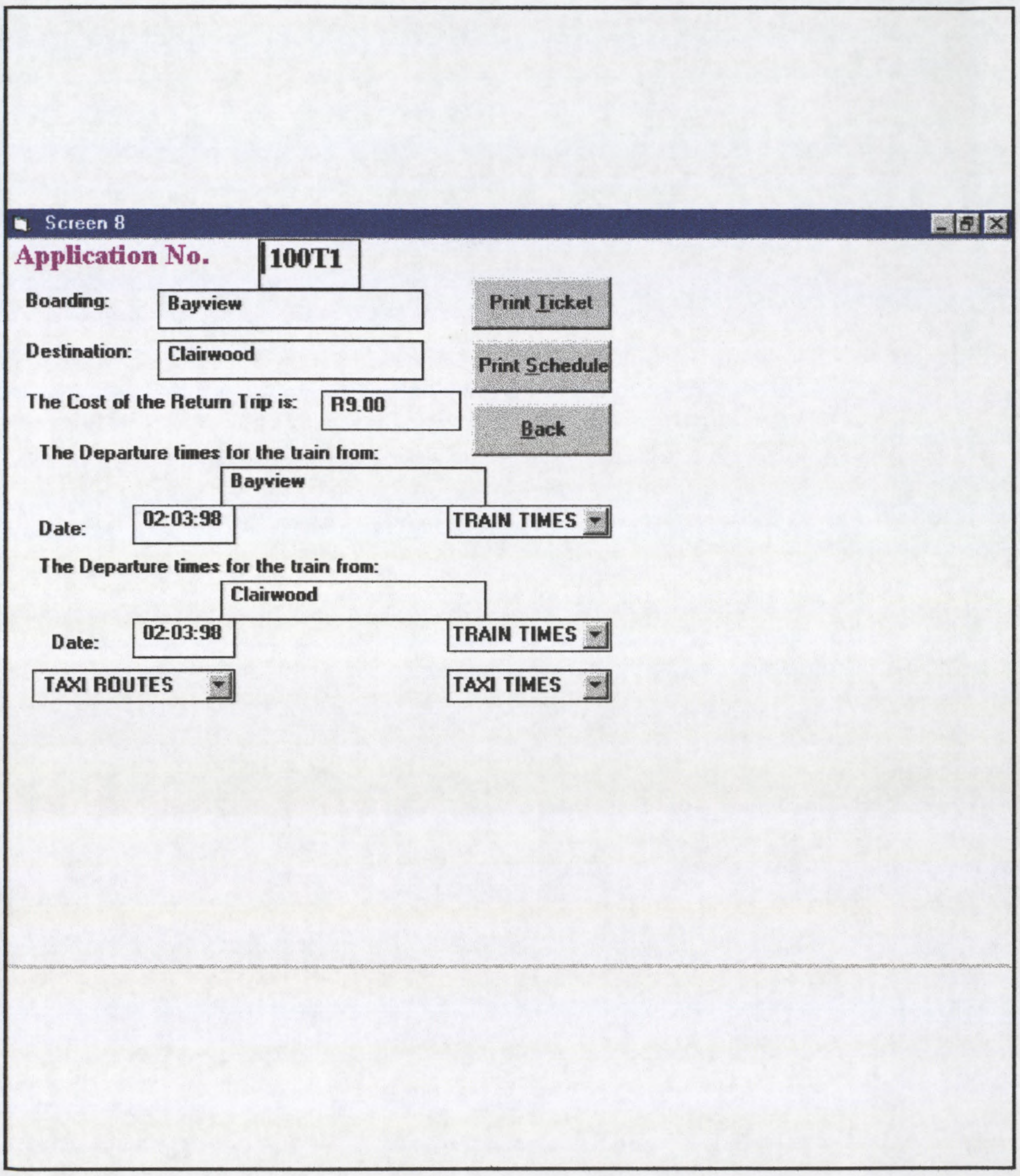


SCREEN 7: Integrated Time-Table

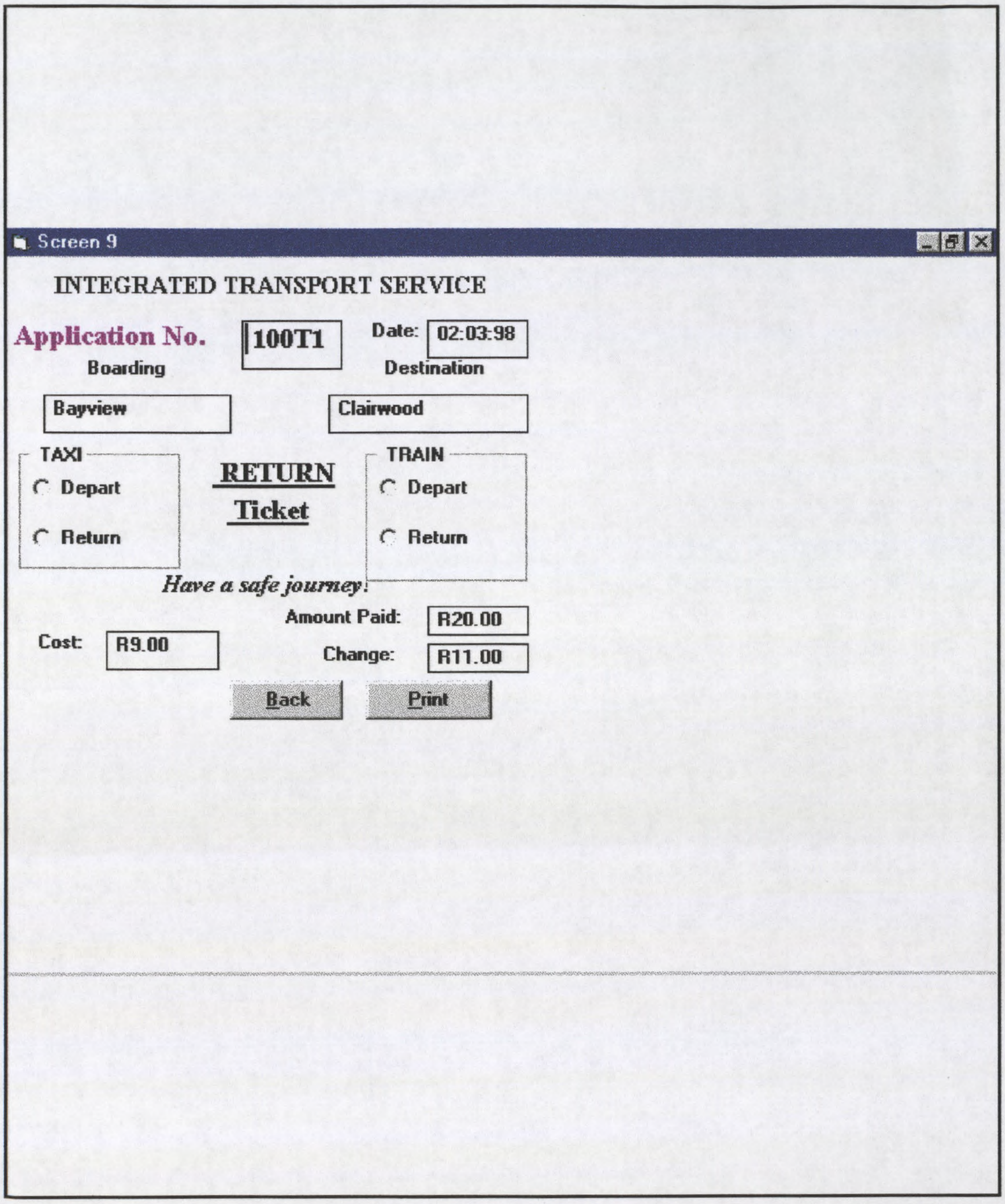
An option is provided to print the hard copy of the schedule if requested by the commuter. The operator can then move backwards to accommodate the next commuters request.

NOTE: All screens provide a BACK option.

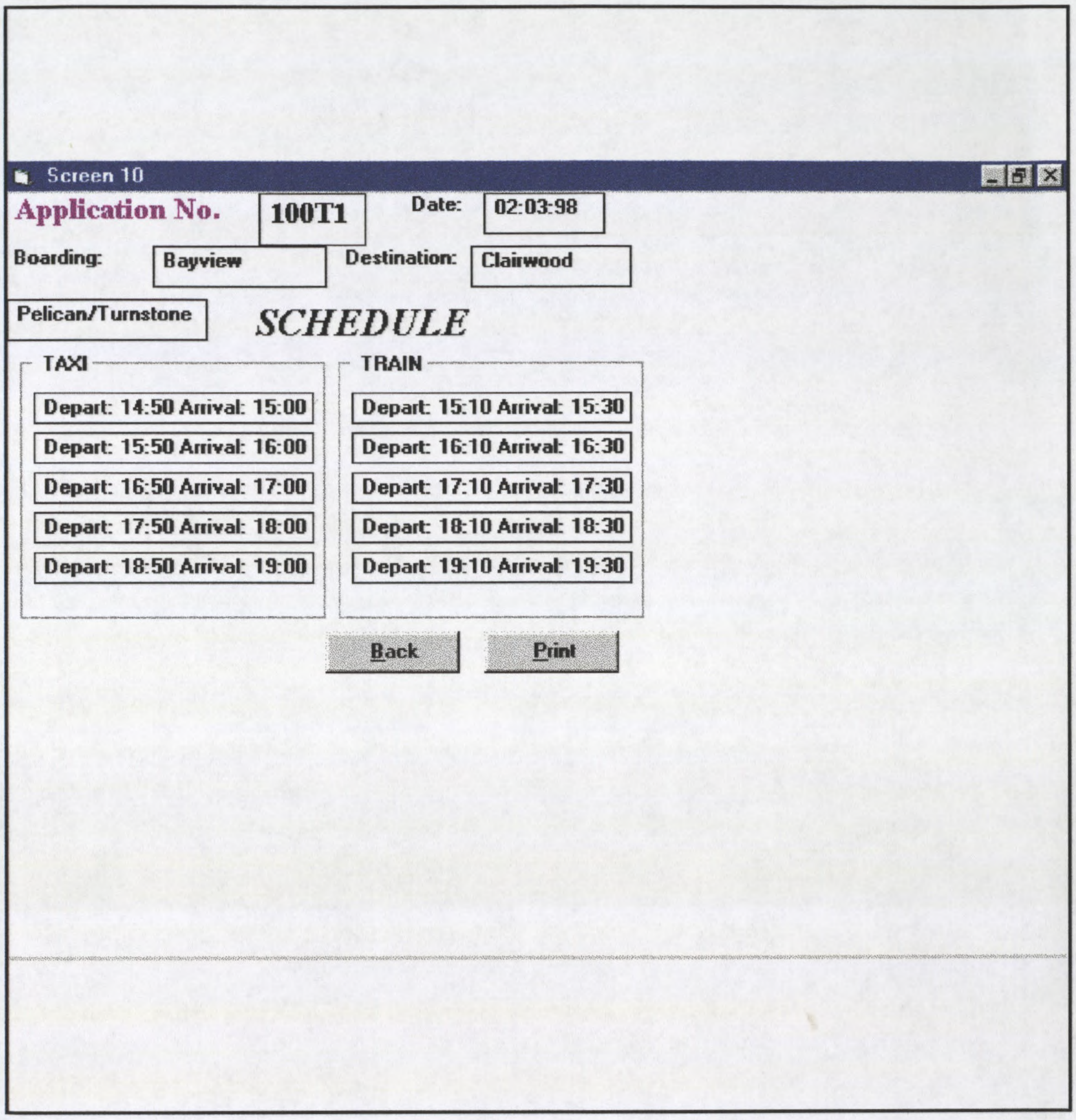
7.5.9 Move backwards to screen 3 and click on Return Ticket. When screen 4 appears, click on Clairwood as the destination option. Screen 8 appears with all the relevant information. As in 7.5.7 and 7.5.8 above, options exist to print the ticket (screen 9) and/or the schedule (screen 10).



SCREEN 8: Travel Information : Return Ticket



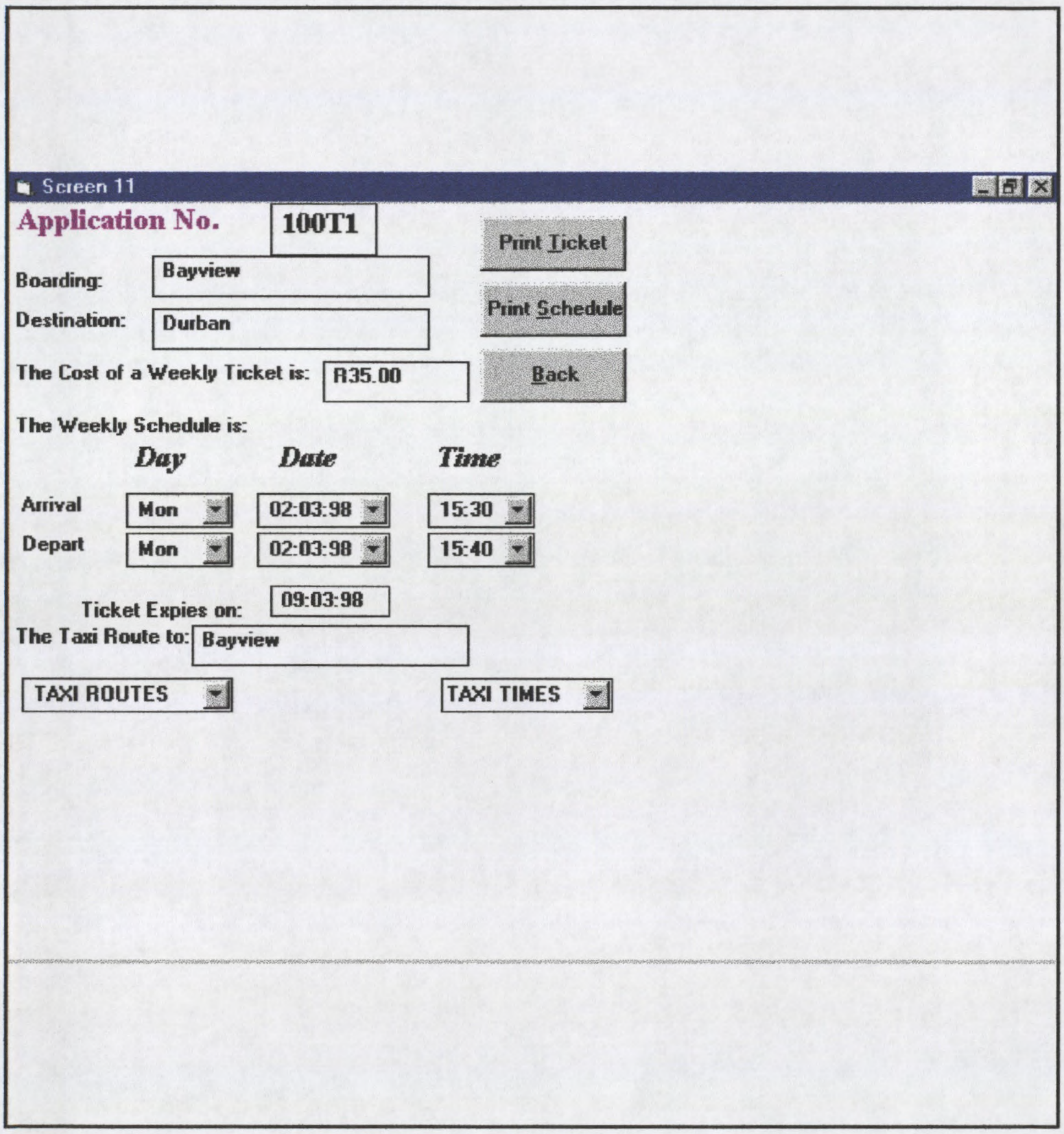
SCREEN 9: Return Ticket



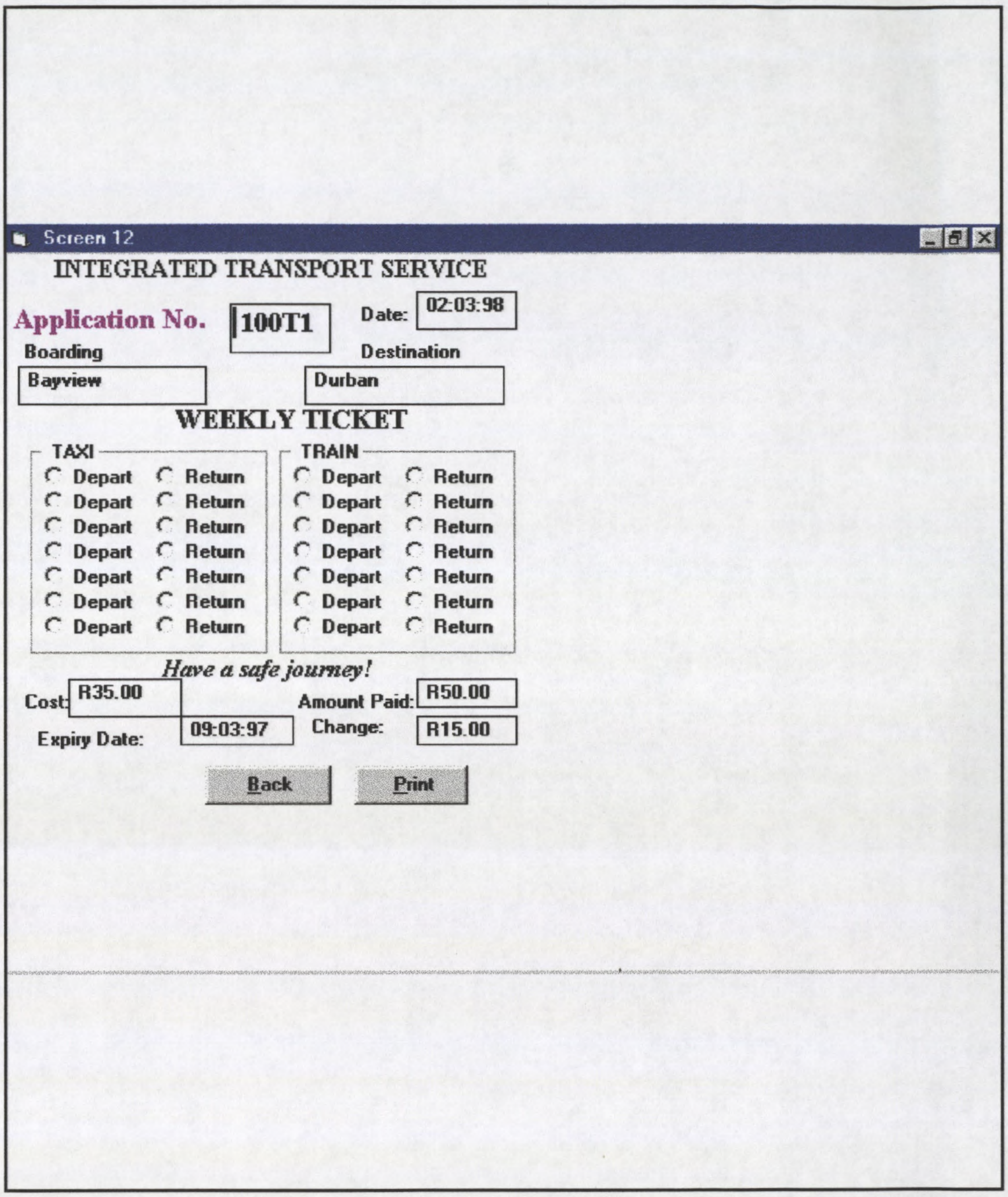
SCREEN 10: Integrated Time-Table

7.5.10 Moving back to screen 3 the process could be repeated choosing the weekly option. When screen 4 appears, click on **Durban** as the destination option.

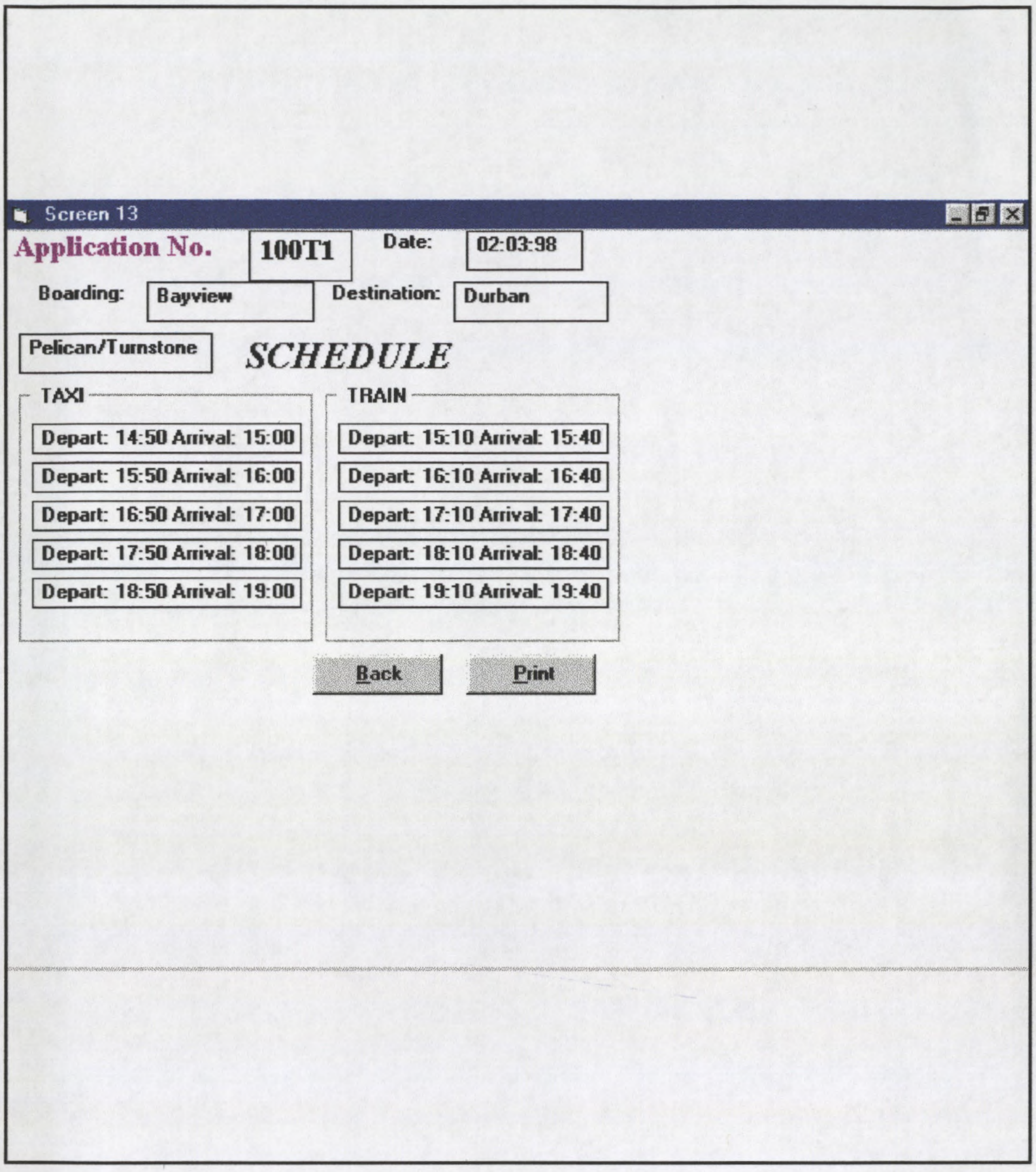
7.5.11 Screen 11 appears with all the relevant information. Following the procedure adopted above, the weekly ticket is reflected on screen 12 and screen 13 displays the integrated ticket (schedule).



SCREEN 11: Travel Information : Weekly Ticket



SCREEN 12: Weekly Ticket



SCREEN 13: Integrated Time-Table

7.6 Cost Analysis of the Proposed Options

It was felt that this chapter would not have been complete if the financial implications of carrying out a pilot project in the study area was not investigated. The approach considered most logical and appropriate was to look at the two "extreme" options namely , the integrated ticket and smart card system. It was further agreed to estimate the approximate cost of conducting a pilot project using one of the stations in the area as a test case and allocating a maximum of fifty taxis to the integrated system. The cost of a full scale pilot project taking into account all five stations and the full commitment from the taxi association in the study area could quite easily be determined/estimated from the "base" calculation.

7.6.1 Cost Estimate : Ticket System

A total of R160 000 was estimated based on the following breakdown:

Hardware :

PC'S :	Server at Chatsworth Centre 1 at a station
Printers :	1 at Chatsworth Centre 1 at a station
Hardware Cost :	R70 000

Software :

Creating Database

Linking of Database

Networking of Computers

Installation

Software Cost : R60 000

Implementation

Testing
User Training

Implementation Cost : R30 000

7.6.2 Cost Estimate : Smart Card System

A total of R320 000 was estimated based on the following :

Hardware :

PC'S : Server at Chatsworth Centre
1 at a station

Printers : 1 at Chatsworth Centre
1 at a station

Machine to produce/update Smart Cards, with printer :

1 at Chatsworth Centre
1 at a station

Validation units for taxis (50 taxis)

Simcard (25 for testing)

Hardware cost : R170 000

Software :

Creating Database
Linking of Database
Networking of Computers
Installation

Software Cost : R100 000

Implementation :

Testing
User Training

Implementation Cost : R50 000

7.7 Conclusion

Although the smart card option appears to be much more expensive, this highly versatile electronic system will certainly control fraud and prove to be much more cost effective over the long term. It should be noted that the prototype is to be used as a requirements analysis technique, that is, as a means of determining the client's real need. Thereafter, written specification documents will have to be produced using the prototype as a basis. The technique adopted will make it easier to proceed with the development and refinement of the prototype until it becomes the product. This approach is therefore a viable technique that can lead to fast software development since the knowledge built into the prototype could be easily converted into the final product.

CHAPTER 8

CONCLUSIONS AND RECOMMENDATIONS

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CONCLUSIONS AND RECOMMENDATIONS

8.1 Introduction

The main objective of this study was to promote effective and efficient use of public transport systems in urban areas of South Africa. Chatsworth, a suburban area of Durban was considered for detailed investigation. As a part of the study, data on the present transport scenario and the perception of the residents about the situation were collected and analyzed. In view of the possible integration, the service requirements of metro rail and the minibus taxi services were analysed based on different demand scenarios in order to determine the optimum service requirement. A methodology has been presented based on data flow diagrams to integrate the minibus taxi and rail services so as to make them more effective and attractive to the residents. A prototype has been developed based on the methodology suggested in order to determine the feasibility of a proposed solution before investing in the full scale development of the target system.

8.2 General Findings

Based on the study, the following general findings have been noted:

. Being the only direct road link connecting Chatsworth with Durban CBD, the traffic on Higginson Highway (M1) has been increasing steadily over the years and is gradually approaching the saturation stage especially during the morning and evening peaks. Traffic volume has increased from 2926 vehicles per hour in 1988 to 4863 vehicles per hour in 1996.

. The accident statistics show a high increase on Higginson Highway and the intersections on it. For example, in one of the intersections on Higginson Highway (with Havenside Drive), the total number of collisions has increased from 52 in 1992 to 95 in 1995.

. Bus transport provides service to about 66% of public transport commuters. The service was first introduced in early 1960s. However, the then government tried to discourage the growth of buses after the introduction of the metro rail system in the Chatsworth area. In the process the service was reduced by about 30% since the introduction of the bus service in the area.

. The existing infrastructure of bus services in the area is highly inadequate with virtually no ranks and very limited bus shelters and lay-byes. No ablution facilities exist for commuters or drivers. In absence of proper facilities, very often the buses are parked on the carriageway affecting the effective width of the roads and hence the flow of traffic.

. Safety on buses is a problem with commuters expressing concern regarding the increase in "pick pockets".

. Minibus taxi started operation in Chatsworth in 1976. The service is mostly limited to the inner circle route. Only recently (December 1995) the Association was granted permission to operate on the Chatsworth - Durban CBD route.

. Taxi feuds, hijacking, overloading and reckless driving are some of the reasons cited by commuters for switching from minibus taxi to private transport.

. Taxi infrastructure is also inadequate with no formal ranks provided.

. The rail transport is highly under-utilized and the available facilities (eg. toilets, benches, taps, etc.) at the stations are inadequate. The patronage on this line peaked some 15 years ago and has been declining steadily ever since. The percentage utilization of the parking bays at four of the five stations range from zero to three percent.

. This rail line is mainly kept "alive" by the domestic workers and school children from Umlazi and neighbouring areas that work/attend classes in the Chatsworth area.

. The escalation of violence and crime and the lack of security at the station car parks has resulted in a distinct shift from rail transport to other modes.

. The distance to the rail station (accessibility), lack of access control, lack of convenient ticket sales offices and restricted hours of ticket sales were all contributing factors leading to the under-utilization of the rail system.

. There is no coordination among bus, taxi and metro rail operations in the area resulting in on-going tension and feuds due to competition of modes. Commuters wishing to use the rail system but reside far off from the stations were not catered for.

. The level of economic activities in the area has increased substantially in recent times. The average monthly household income has increased from R2020 in 1991 to R3000 in 1995. This may be one of the reasons for the increase in car ownership in the area.

. On an average, approximately 14% of the family's net monthly income is spent on transport. About 83% of the families interviewed have school and/or college going members thus indicating a high employment demand in the future. This would have an impact on the only major access road from the area to the Durban CBD.

. In spite of the frequent traffic congestion on the Higginson Highway, a high percentage of the commuters still prefer using their motor vehicles to work. The main reasons for using cars as indicated by the residents include convenience, reliability and safety. The modal split in the study area is: car : 52.3%, bus : 31.4%, taxi : 11.7% and train : 4.6%.

. Most of the car users are unhappy with the present traffic condition. They do not consider rail as an option due to, amongst other factors, the lack of accessibility to the stations. However, approximately 80% of them indicated that they would prefer rail if the following factors were improved:

. Secured parking at the station.

. Security while travelling.

. Improved frequency of service.

. Minibus service from their locality to the station.

. The public transport modal split is : bus : 65.8%, taxi : 24.5% and train : 9.7%. The commuters feel that the quality of overall service provided by the public transport modes is not satisfactory. Rail users show greater discontent in comparison with bus and taxi commuters. It shows that the level of service provided by the rail system was generally much lower than that provided by bus or taxi.

. Personal security on rail transit has been found to be dissatisfactory among the residents.

. The methodology developed on data flow diagrams (DFD) in this study will help to integrate different modes. This integration technique developed in the study helped in providing an overview of data movement through the system thus allowing the project team to detect and correct errors and design flaws at the early stages of systems development.

. The prototype developed based on DFD has been found to be working perfectly in modal integration. The smart card system may be the most cost effective in the long run. The simulation model developed proved that the possibility of carrying out a full scale pilot project in the study area is a viable option.

. The methodology for demand analysis will help to project the future total demand in the study area. The analysis also indicates that there is considerable potential to increase the capacity of the rail line when compared with the current scheduled service.

8.3 Conclusions

In Chapter one, six specific objectives were established for this study (Page 15). The first two objectives entailed far more time and effort than had originally been anticipated, but were eventually achieved in Chapters three and four. The third objective - *to study the service requirements of the metro rail and minibus taxi services in the study area with different demand scenarios* - has been presented in Chapter 5. The next two objectives, namely, *to develop a methodology for the integration of public transport modes* and *to develop a prototype based on the methodology* were presented in Chapter 6 and Chapter 7. The final objective was *to suggest broad policy guidelines and recommendations to make public transport attractive.* These recommendations appear in the next section of this chapter.

The following conclusions have been drawn from this research work:

A large percentage of the population who use cars, are willing to shift to public transport modes provided proper accessibility and facilities are provided.

Based on the existing land-use pattern of the study area and the alignment of the metro rail system, integration of the public transport modes, ie. metro rail and minibus taxi is the only way to increase the patronage on metro rail in the short run.

The methodology developed in this study based on DFD technique can be effectively applied to modal integration in the area. Even though it has been applied to integrate only metro rail and minibus taxi in this study, it can be used for a number of modes.

The prototype developed in this study shows the versatility of the methodology developed for integration of public transport modes. It has the structure that could lead to the development of a full scale target system.

The demand analysis carried out in this study helps the planners to determine the adequacy of the present public transport infrastructures and services. This also helps to determine the services to be provided in an integrated system to cater for a certain demand.

8.4 Recommendations

Integration of public transport modes is one of the many steps to be taken in order to achieve the policy goals and objectives of attracting more people towards transit as reflected in the white paper on National Transport Policy. Based on the present study, the following recommendations are made:

Urgent attention to be given to the station car parks in the form of fencing and permanent security. Metro Rail should also consider providing car parks at the Bayview Station (Umhlatuzana access) and Westcliff Station

(Woodhurst access). Park and ride facilities have already been developed at all five stations but were badly neglected, poorly managed and lacked security. The proper control and implementation of this facility will theoretically combine the convenience of the car in the survey area with the uncongested travel offered by the rail service. This will avoid the effort of driving cars on the already congested Higginson Highway, finding parking and having to pay high parking costs in the CBD.

The dense bush surrounding some of the station areas be immediately cleared in order to create a feeling of safety and at the same time destroying places of concealment to would-be thugs. It is essential to create a positive image around the stations by undertaking beautification projects, building of plazas/shopping centres and social meeting places.

24-hour security to be provided on all platforms and station buildings to prevent further damage to fittings, equipment and infrastructure. Strong security should also be provided in running trains for the passengers. Fear of crime is clearly a deterrent to using public transport. The most important types of crime occurring on trains are robberies and assaults. One approach to this problem is to have police patrol the stations and ride on trains. Metro Rail should seriously consider the option of engaging a team of undercover agents that roam the system. This strategy could prove very effective if properly implemented in spite of this approach being labour-intensive and costly. Stronger or brighter lighting will increase the feeling of security at the stations. The installation of television cameras that scan the station is also a viable option. The presence of security personnel at interchange points is vital in order to protect and further attract passengers since much of the violence affecting public transport has taken place at points of interchange.

The immediate installation of security fencing to prevent commuters, especially scholars from crossing over the railway lines and the Higginson Highway which perpetually operates at forced flow conditions during the morning and afternoon peaks. At least three scholars have already lost their lives while attempting to cross the railway lines and the provision of security fencing will certainly prevent further tragedies from occurring.

Provision should be made for the establishment of formal ranks with the associated infrastructure and facilities, inclusive of shelters and bays along the scheduled routes. The determination of the optimum spacing and provision of lay byes with route markings/information should be pursued. The existing facilities should be upgraded and maintained to at least an acceptable standard (toilets, taps, lighting, benches, etc.).

The Westcliff station building should be relocated centrally in order to cater for commuters from both sides of the Higginson Highway. Metro Rail should also consider leasing a ticket office at the Chatsworth Centre shopping complex where the bulk of the residents from this area make their purchases.

Driving hours should be staggered so as to overcome long hours which could lead to driver fatigue and accidents. The taxi and bus associations should be responsible for determining a roster system.

The frequency of service provided during the peak period should be adjusted in order to overcome the problem of crowding. Off-peak frequency should also be adjusted to reduce waiting times.

Security to be provided on buses to curb the existing problem experienced by commuters with regard to "pickpockets". In order to promote safety within the minibus taxi industry, the taxi association should combine forces with the SAPS in the area in forming a safety unit to check, monitor and control the entire operation. A complaints office should be set up by the minibus taxi association to handle complaints received from drivers, owners and commuters.

Public transport operators should develop stronger links with the community/community organisations in order to obtain feedback and ideas of how to meet the challenges and to assist in eliminating violence, robbery, highjacking, etc. which have been common phenomenon in recent years.

A stronger relationship should be established between the Bus Association and the Taxi Association in the area in order to determine a route schedule and timetable that is acceptable to both modes. Both the Associations have recently developed strong ties by setting up meetings to discuss illegal minibus operation and to generally strengthen control and regulation in the industry.

Refurbishing of all existing coaches in order to provide a better service and increase the present level of comfort. Lower rail noise can be achieved by better track maintenance and by modification of the rail vehicles, particularly the wheels and bogies.

The establishment of formal roads directly linking the surrounding areas. For example, there are no formal roads between Chatsworth and Lamontville although commuting between the two areas do occur. Provision of formal links between these areas could reduce some burden on the Higginson Highway.

Efforts should be initiated now for the development of high density commercial and residential complexes along the metro rail alignment. The developers may be offered incentives to develop along the route. This will attract passengers to metro rail. Because of surrounding developed areas the safety at the stations will also increase.

Future transportation planning process to interlink factors such as residential population, employment, retailing and transport. In an attempt to consider these interrelationships, a range of integrated models can be developed. Integrated models will certainly have an advantage since they may be used to estimate a land-use allocation and the associated travel demands simultaneously. In the past transportation planning was done based on a sequential series of models which dealt with individual parts of the problem (ie. trip generation, trip distribution, modal split and traffic assignment). This approach of separating the process into elements or stages had its shortcomings since it was very often divorced from reality. Whilst some integrated land-use models have been developed, various shortfalls have been identified over the years. Some models were unable to predict the situation in intervening years and also assumed that at the end of every forecast period all the regions elements and activities were in equilibrium which is most often not the case.

A partnership should be developed between Metro Rail and the Chatsworth Minibus Association in providing a feeder service to the stations with the establishment of drop-off zone. The Minibus Association has already moved a step closer by using one of the station's car parks as a taxi rank. The methodology suggested in Chapter 6 should be seriously considered in terms of developing a target system for the operational analysis of minibus-rail integration. It is proposed that a pilot project be carried out in the survey area to demonstrate practically the integrated system suggested. It is important that the necessary information required for effective intermodal transfers be presented to the user/commuter in an easy, user friendly format in order to prevent possible delays and frustration.

The taxi route network in the area should be initially adjusted in accordance with the demand from commuters wishing to use the integrated system until such time the "optimum" request is reached. This procedure will also assist the permit issuing authorities with regard to demand determination. The colour coding and route numbering of minibus taxis allocated to the integrated system will be necessary in order to distinguish between those taxis operating the inner circle route. Lay byes should also be properly numbered reflecting intermediate stops and final destination. In the case of taxis allocated to the integrated system, the final destination from the rank will be one of the five railway stations in the area.

The five stations in the area should be revamped by "converting" them into modal interchange nodes with the establishment of drop-off zones, holding areas, passenger shelters and walkways. This process will also empower local entrepreneurs and create new jobs.

The Department of Transport and the South African Rail Commuter Corporation (SARCC) are considering innovative ways of restructuring commuter rail services in South Africa. A discussion document was released in order to inform and stimulate the debate around the options of concessioning or franchising certain services to different operators. The Chatsworth Minibus Association should seriously consider the options proposed by the Department of Transport and the SARCC with regard to restructuring the commuter rail services in South Africa. The concept of rail concessioning and the various choices/options available for discussion should be carefully studied and supported since it is important for the taxi industry to have some form of "ownership" of the Chatsworth Spur in order to be fully committed to the modally integrated system proposed. The Department of Transport together with SARCC should investigate the feasibility of introducing a demonstration project for concessioning on the Chatsworth rail line.

Large companies such as financial houses, food chain stores, motor and trade industries, etc. should be allowed advertising rights at the stations in exchange of providing the necessary services such as cleaning, maintenance and general upkeep of the station buildings, platforms and surroundings. This would further enhance the safety at the stations.

The access control should be improved/upgraded to incorporate combined weekly/monthly tickets issued through electronic ticket - issuing machines and card readers at the entrances and exits to stations, bus and minibus. The integrated system proposed in Chapter 6 will warrant the need for the above factors.

The following recommendations are based on broad policy guidelines in the form of planning, education and enforcement to attract more commuters to public transport so that the target modal split between public transport and car can be achieved in the long run:

Serious efforts need to be made to improve marketing in public transport. Public transportation is a service that needs to be sold to the public. Most operators devoted very little of their budgets to advertising, public relations and promotions. There needs to be a greater deal of consumer research to determine what commuters need and want and developing services to satisfy them. Bill boards promoting public transport should be erected on all major links leading to the CBD as part of the advertising campaign. Most public transport operators recognise the importance of providing information on their services to the public but very often fail to "deliver" on this aspect. It is important to provide practical information for commuters eg. a map of the route and a time table showing the scheduled arrivals at a stop. It is further necessary to expand the role of marketing from advertising and promotion to include market research and evaluation.

The general public should be made aware of the disadvantages of using of cars and the advantages of using public transport. Educating the public could be achieved via the various electronic and print media available in the region. It is also very important to target the school pupils so that they are made aware of the facts at a very young age in order to work towards the goal of 80:20 in the year 2020.

An area licensing scheme which requires cars to have a pre-purchased licence to enter the city centre in the morning peak should be investigated. The implementation of a similar scheme in Singapore introduced in 1975 showed an immediate drop of 70% in the number of cars entering the licensed area. Despite growth of the city population by over 30% since, it is still 20% below pre-scheme levels. Car modal share fell from 46% in 1974 to 22% in 1988 whilst that of public transport was up from 46 to 63 percent (Black,1995).

Department of Transport should give priority to the provision of transport funding including subsidisation that is aimed at promoting integrated systems. This should include training programmes that will enhance communication between operators and commuters as well as highlighting aspects relating to traffic safety. It is proposed that a joint partnership be developed between the minibus taxi industry and tertiary institutions in developing and offering training programmes so desperately needed in this industry. Short courses, lectures , seminars and workshops should be structured to suite the minibus taxi industry and delivered by specialists from industry as well as academics mainly in the fields of basic economics of running a taxi or a fleet of taxis, traffic rules and regulations and public relations. Incentives could include a certificate presentation ceremony at the end of the programme. Incentives could also be linked to the point system that is currently being proposed.

Minibus taxis can play a vital role in educating and making people aware of road safety, drugs, aids, child abuse, etc. by using them as "advertising vehicles". Since it is estimated that they provide transport to about 2.2 million South Africans, almost half the country's commuter service, this method of advertising will prove effective.

Although law enforcement workshops are being held with traffic authorities to trash out ways of implementing the laws to control the mushrooming taxi industry, carrying them out has not been very effective. The Government has the resources to enforce these laws and requires greater commitment and dedication by the traffic authorities in order to initiate stricter enforcement blitzes.

The structure of regulating and controlling operators and associations, as proposed by the National Taxi Task Team, must be actively pursued in order to see lasting and positive changes. The current policies, such as regulation of the minibus taxi industry can certainly assist with the integration of transport services and every effort must be made to formulate future transport policies to facilitate integration.

8.5 Additional Recommendations

While every effort must be made to implement and support the modally integrated system suggested, the following recommendations are worthy options in favour of public transport. However, cognizance must be given to the fact that it will not be viable to implement some of these recommendations concurrently with the modally integrated system since they could impede on the success of this system:

. Measures could be taken to encourage higher occupancies of cars in an attempt to reduce the number of cars on the roads at peak period. A single lane on Higginson Highway could be set aside purely for high occupancy vehicles (HOV's) and public transport.

. Bike-and-ride strategies should be investigated in order to establish further opportunities for increased public transport system efficiency. Efforts should be made to transfer low-cost human-powered transportation technologies from Asian countries, where they have been successful, to South Africa.

8.6 Scope for Further Investigations

The methodology developed has been applied in a very limited study. However, the technique could quite easily be applied to other areas experiencing similar problems. It is only when these problems have been resolved appropriately at the micro-level, that problematic issues at a macro-level can be effectively managed. Some of the topics of further research/investigation are:

. Conducting a pilot project in the study area to demonstrate practically how the integrated system would work.

. Application of the technique on data flow diagrams to transit route network planning.

. In-depth study on the demand analysis of the survey area with regard to individual routes.

. A full investigation into the viability of concessioning/franchising the Durban-Crossmoor line and the possibilities of the Chatsworth Minibus Association gaining "ownership" of this line.

. Development of a modal split model for Charsworth.

. Determination of the impact of crime on the patronage of public transport modes.

. Development of a transport-landuse model for Chatsworth to make it public transport friendly.

. Economic analysis of the congestion and accidents on Higginson Highway and the underutilization of metro rail services.

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APPENDIX A

Survey Questionnaire 1 : To establish commuter attitudes, preferences and priorities concerning the existing transport system serving the greater Chatsworth area.

TOWARDS A MORE EFFECTIVE AND EFFICIENT PUBLIC TRANSPORT SYSTEM : A CASE STUDY

Hello, I am conducting a survey in your area to identify and evaluate the existing transportation system.

Your feedback will tremendously assist in determining whether the present transportation situation is acceptable/adequate.

I do not need to know your name or address and all your answers will be kept confidential.

The data will be used only for research purposes.

You need to only circle the correct answer.

"Taxi" in this questionnaire refer to mini-bus taxi

Work trips include trips made for educational purposes

Thank you for your valuable time.

SURVEY QUESTIONNAIRE

1. Your MAIN mode of transport to work :

car	1
bus	2
train	3
taxi	4

2. Distance from home to work place (km) :

less than 10	1
10 - 20	2
21 - 30	3
31 - 40	4
more than 40	5

3. Your sex :

Male	1
Female	2

4. Indicate the number of family members in your household:

less than 3	1
3 - 5	2
6 - 8	3
9 - 11	4
more than 11	5

5. Number of employed persons in the household :

none	1
1	2
2	3
3	4
4	5
more than 4	6

6. Indicate the number of school and college going members in the household :

none	1
1	2
2	3
3	4
4	5
more than 4	6

7. Number of cars in the household:

none	1
1	2
2	3
3	4
more than 3	5

8. Your occupation :

professional/managerial	1
skilled white collar	2
skilled blue collar	3
unskilled	4
informal sector	5
student	6
other (please specify)	7 ____________________

9. Indicate your age group :

below 20	1
20 - 25	2
26 - 35	3
36 - 45	4
46 - 60	5
over 60	6

10. Average monthly expenditure on transport for the household/family (rands) :

less than 200	1
200 - 300	2
301 - 400	3
401 - 500	4
501 - 600	5
more than 600	6

11. Your family's average NET (take home) monthly income (rands) :

less than 1000	1
1000 - 2000	2
2001 - 3000	3
3001 - 4000	4
4001 - 5000	5
more than 5000	6

---

12. If the private motor car is your mode of transport to work, then please answer questions 12.1 to 12.11

12.1 How long does it take you to get to work (minutes)?

Less than 10	1
10 - 20	2
21 - 30	3
31 - 40	4
more than 40	5

12.2 What is your opinion about the time taken?

Highly satisfactory	1
Satisfactory	2
Acceptable	3
Dissatisfactory	4
Highly dissatisfactory	5

12.3 What is your opinion of the traffic condition to and from work?

Highly congested	1
Congested	2
Acceptable	3
Partly free flow	4
Completely free flow	5

12.4 *Indicate the three most important factors that encourage you to use the motor car:*

Convenience/accessibility	1
Safety	2
Comfort	3
Cost	4
Journey time	5
Reliability	6

12.5 *Indicate the three most important reasons why you do not use public transport (bus, rail, taxi) :*

Stop/station too far	1
Frequency of service not satisfactory	2
Journey time too long	3
Too crowded	4
Not reliable	5
Not safe	6

12.6 *If the above factors were improved, will you consider using the public transport system (either bus, rail or taxi)?*

Yes	1
No	2

12.7 *Which of the following modes do you consider as a possible alternative for going to work?*

Bus	1
Rail	2
Taxi	3
None	4

12.8 *What would you consider as an acceptable distance to walk at the origin and destination ends of public transport stops/station (meters)?*

Less than 100	1
100 - 200	2
201 - 300	3
301 - 400	4
401 - 500	5
501 - 600	6
More than 600	7

12.9 What would you consider as an acceptable waiting time for the public transport (minutes)?

less than 5	1
5 - 10	2
11 - 15	3
16 - 20	4
more than 20	5

12.10 How far is the nearest rail station from your home(meters)?

less than 100	1
100 - 300	2
301 - 500	3
501 - 700	4
701 - 900	5
more than 900	6

12.11 Which are the factors you consider most important to be improved to make you consider rail as an alternative?

Secured parking at stations	1
Security at platforms	2
Security while travelling	3
Increased frequency of service	4
Bus/minibus services from your locality to station and destination station to your work place	5
Improved comfort on the train	6

---

13. If you use the public transport system to work, then please answer questions 13.1 to 13.10

13.1 Indicate which mode of public transport you use:

Bus	1
Rail	2
Taxi	3

13.2 How long do you spend walking to the bus stop/station from where you live (minutes)?

less than 10	1
10 - 15	2
16 - 20	3
21 - 25	4
more than 25	5

13.3 What is your opinion of the time taken?

Highly satisfactory	1
Satisfactory	2
Acceptable	3
Dissatisfactory	4
Highly dissatisfactory	5

13.4 How long do you spend waiting at the beginning of your work trip for the public transport to arrive (minutes)?

less than 5	1
5 - 10	2
11 - 15	3
16 - 20	4
more than 20	5

13.5 Indicate the travelling time to get to work (minutes) :

less than 10	1
10 - 20	2
21 - 30	3
31 - 40	4
more than 40	5

13.6 How long do you spend walking from the bus stop/station to work (minutes)?

less than 5	1
5 - 10	2
11 - 15	3
16 - 20	4
more than 20	5

13.7 What is your opinion of the overall service that is being provided?

Excellent	1
Good	2
All right	3
Poor	4
Bad	5

13.8 How would you rate the safety aspect on your mode of transport?

Highly satisfactory	1
Satisfactory	2
Acceptable	3
Dissatisfactory	4
Highly dissatisfactory	5

13.9 How would you assess the adequacy of the facilities/infrastructure provided (eg. bus ranks, bus shelters, stations, ticket offices, time schedule, etc.)?

Excellent	1
Adequate	2
Barely adequate	3
Inadequate	4
Terrible	5

13.10 List three factors from below that you consider most important to be improved regarding your mode of transport?

Convenience/accessibility	1
Safety/security	2
Comfort	3
Frequency of service	4
Reliability	5
Journey time	6
Cost	7

---

14. Any other comments you would like to make?

____

____

____

____

THANK YOU ONCE AGAIN FOR YOUR VALUABLE TIME.

APPENDIX B

Survey Questionnaire 2 : To determine commuter perception of personal security on rail transport.

COMMUTER PERCEPTIONS OF PERSONAL SECURITY ON RAIL TRANSPORT

Hello, I am conducting a survey to establish the nature and extent of the problem regarding the personal security of rail users on this line. Your feedback will certainly assist in determining whether there is an urgent need to increase the levels of safety experienced by rail commuters. All the questions below are related to your work trip while using the rail system. Work trips include trips made for educational purposes. I do not need to know you name and address and all you comments will be kept confidential. The data will be used only for research purposes. Thank you for your valuable time.

If your response to any of the following questions (Q1-Q3) is "yes", please explain very briefly.

Q1. Did you or a family member personally experience any crime?

____

____

____

Q2. Did you or a family member witness any violence or crime?

____

____

____

Q3. Did you hear of any criminal incidents from others?

____

____

____

Q4. What do you feel could be done (if any) to make the rail system more safe?

____

____

____

____

____

Q5. Are there any other comments that you would like to make with regard to the safety aspect?

____

____

____

____

____

Thank you once again for your valuable time

APPENDIX C

"Frequency Tables" (Data Analysis) : Survey Questionnaire 1

SPSS/PC+ The Statistical Package for IBM PC

```
GET /FILE 'fintran7.sys'.
The SPSS/PC+ system file is read from
    file fintran7.sys
The file was created on  8/14/96 at 15:17:54
and is titled SPSS/PC+ System File written by Data Entry
The SPSS/PC+ system file contains
    325 cases, each consisting of
     49 variables (including system variables).
     49 variables will be used in this session.
```

This procedure was completed at 19:45:57

```
FREQUENCIES /VARIABLES AREA Q1 Q2 Q3 Q4 Q5 Q6 Q7 Q8 Q9 Q10 Q11 Q12.1 Q12
Q12.3 Q12.4_1 Q12.4_2 Q12.4_3 Q12.5_1 G12.5_2 Q12.5_3 Q12.6 Q12.7 Q12.8
Q12.10 Q12.11_1 Q12.11_2 Q12.11_3 Q12.11_4 Q12.11_5 Q12.11_6 Q13.1 Q13.2
Q13.4 Q13.5 Q13.6 Q13.7 Q13.8 Q13.9 Q13.10_1 Q13.10_2 Q13.10_3 /STATISTI
```

***** Memory allows a total of 10614 Values, accumulated across all
There also may be up to 1326 Value Labels for each Variable.

AREA Area code

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	25	7.7	7.7	7.7
	2	25	7.7	7.7	15.4
	3	25	7.7	7.7	23.1
	4	25	7.7	7.7	30.8
	5	25	7.7	7.7	38.5
	6	25	7.7	7.7	46.2
	7	25	7.7	7.7	53.8
	8	25	7.7	7.7	61.5
	9	25	7.7	7.7	69.2
	10	25	7.7	7.7	76.9
	11	25	7.7	7.7	84.6
	12	25	7.7	7.7	92.3
	13	25	7.7	7.7	100.0
	TOTAL	325	100.0	100.0	

AREA Area code

Mean	7.000	Std Dev	3.747	Minimum	1.000
Maximum	13.000				

Valid Cases 325 Missing Cases 0

Q1 Main mode of transport

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percen
	1	170	52.3	52.3	52.3
	2	102	31.4	31.4	83.7
	3	15	4.6	4.6	88.3
	4	38	11.7	11.7	100.0
	TOTAL	325	100.0	100.0	

Mean	1.757	Std Dev	.990	Minimum	1.000
Maximum	4.000				

Valid Cases 325 Missing Cases 0

Q2 Distance from home to work place

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	25	7.7	7.7	7.7
	2	73	22.5	22.5	30.2
	3	94	28.9	28.9	59.1
	4	33	10.2	10.2	69.2
	5	100	30.8	30.8	100.0
	TOTAL	325	100.0	100.0	

Mean	3.338	Std Dev	1.325	Minimum	1.000
Maximum	5.000				

Valid Cases 325 Missing Cases 0

Q3 Sex

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	239	73.5	73.5	73.5
	2	86	26.5	26.5	100.0
	TOTAL	325	100.0	100.0	

Mean	1.265	Std Dev	.442	Minimum	1.000
Maximum	2.000				

Valid Cases 325 Missing Cases 0

Page 9 SPSS/PC+

Q4 Number of family members in household

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percen
	1	18	5.5	5.5	5.5
	2	226	69.5	69.5	75.1
	3	75	23.1	23.1	98.2
	4	3	.9	.9	99.1
	5	3	.9	.9	100.0
	TOTAL	325	100.0	100.0	

Mean 2.222 Std Dev .598 Minimum 1.000
Maximum 5.000

Valid Cases 325 Missing Cases 0

Page 10 SPSS/PC+

Q5 Number of employed persons in household

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percen
	1	6	1.8	1.8	1.8
	2	167	51.4	51.4	53.2
	3	105	32.3	32.3	85.5
	4	36	11.1	11.1	96.6
	5	9	2.8	2.8	99.4
	6	2	.6	.6	100.0
	TOTAL	325	100.0	100.0	

Mean 2.634 Std Dev .856 Minimum 1.000
Maximum 6.000

Valid Cases 325 Missing Cases 0

Page 11 SPSS/PC+

Q6 Number of school and college going membe

Value Label	Value	Frequency	Percent	Valid Percent	Cum Perce
	1	56	17.2	17.2	17.
	2	125	38.5	38.5	55.
	3	117	36.0	36.0	91.
	4	24	7.4	7.4	99.
	5	3	.9	.9	100.
	TOTAL	325	100.0	100.0	

Mean 2.363 Std Dev .884 Minimum 1.000
Maximum 5.000

Valid Cases 325 Missing Cases 0

Q7 Number of cars in the household

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	59	18.2	18.2	18.2
	2	184	56.6	56.6	74.8
	3	67	20.6	20.6	95.4
	4	14	4.3	4.3	99.7
	5	1	.3	.3	100.0
	TOTAL	325	100.0	100.0	

Mean 2.120 Std Dev .758 Minimum 1.000
Maximum 5.000

Valid Cases 325 Missing Cases 0

Q8 Occupation of respondent

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	34	10.5	10.5	10.5
	2	100	30.8	30.8	41.2
	3	134	41.2	41.2	82.5
	4	22	6.8	6.8	89.2
	5	5	1.5	1.5	90.8
	6	24	7.4	7.4	98.2
	7	6	1.8	1.8	100.0
	TOTAL	325	100.0	100.0	

Mean 2.877 Std Dev 1.344 Minimum 1.000
Maximum 7.000

Valid Cases 325 Missing Cases 0

Q9 Respondent's age

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	15	4.6	4.6	4.6
	2	47	14.5	14.5	19.1
	3	89	27.4	27.4	46.5
	4	135	41.5	41.5	88.0
	5	34	10.5	10.5	98.5

	6	5	1.5	1.5	100.0
	TOTAL	325	100.0	100.0	

Mean 3.434 Std Dev 1.057 Minimum 1.000
Maximum 6.000

Valid Cases 325 Missing Cases 0

Q10 Monthly expenditure on transport for hou

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	60	18.5	18.5	18.5
	2	100	30.8	30.8	49.2
	3	83	25.5	25.5	74.8
	4	49	15.1	15.1	89.8
	5	19	5.8	5.8	95.7
	6	14	4.3	4.3	100.0
	TOTAL	325	100.0	100.0	

Mean 2.720 Std Dev 1.321 Minimum 1.000
Maximum 6.000

Valid Cases 325 Missing Cases 0

Q11 Family's net monthly income

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	11	3.4	3.4	3.4
	2	53	16.3	16.3	19.7
	3	102	31.4	31.4	51.1
	4	102	31.4	31.4	82.5
	5	36	11.1	11.1	93.5
	6	20	6.2	6.2	99.7
	7	1	.3	.3	100.0
	TOTAL	325	100.0	100.0	

Mean 3.502 Std Dev 1.188 Minimum 1.000
Maximum 7.000

Valid Cases 325 Missing Cases 0

Q12.1 How long does it take you to get to work

Valid Cum

Value Label	Value	Frequency	Percent	Percent	Percen
	1	4	1.2	2.4	2.4
	2	30	9.2	17.6	20.0
	3	57	17.5	33.5	53.5
	4	46	14.2	27.1	80.6
	5	33	10.2	19.4	100.0
	.	155	47.7	MISSING	
	TOTAL	325	100.0	100.0	

Mean 3.435 Std Dev 1.065 Minimum 1.000
Maximum 5.000

Valid Cases 170 Missing Cases 155

Q12.2 Time by car to work

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	1	.3	.6	.6
	2	15	4.6	8.8	9.4
	3	74	22.8	43.5	52.9
	4	57	17.5	33.5	86.5
	5	23	7.1	13.5	100.0
	.	155	47.7	MISSING	
	TOTAL	325	100.0	100.0	

Mean 3.506 Std Dev .858 Minimum 1.000
Maximum 5.000

Valid Cases 170 Missing Cases 155

Q12.3 Traffic condition to and from work by ca

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	74	22.8	43.5	43.5
	2	70	21.5	41.2	84.7
	3	25	7.7	14.7	99.4
	4	1	.3	.6	100.0
	.	155	47.7	MISSING	
	TOTAL	325	100.0	100.0	

Mean 1.724 Std Dev .730 Minimum 1.000
Maximum 4.000

Valid Cases 170 Missing Cases 155

Page 20 SPSS/PC+

Q12.4_1 1st factor

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	150	46.2	88.2	88.2
	2	15	4.6	8.8	97.1
	3	5	1.5	2.9	100.0
	.	155	47.7	MISSING	
	TOTAL	325	100.0	100.0	

Mean 1.147 Std Dev .431 Minimum 1.000
Maximum 3.000

Valid Cases 170 Missing Cases 155

Page 21 SPSS/PC+

Q12.4_2 2nd factor

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	2	69	21.2	40.8	40.8
	3	71	21.8	42.0	82.8
	4	4	1.2	2.4	85.2
	5	24	7.4	14.2	99.4
	6	1	.3	.6	100.0
	.	156	48.0	MISSING	
	TOTAL	325	100.0	100.0	

Mean 2.917 Std Dev 1.026 Minimum 2.000
Maximum 6.000

Valid Cases 169 Missing Cases 156

Page 22 SPSS/PC+

Q12.4_3 3rd factor

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	1	.3	.6	.6
	3	21	6.5	12.4	13.0
	4	3	.9	1.8	14.8
	5	16	4.9	9.5	24.3
	6	128	39.4	75.7	100.0
	.	156	48.0	MISSING	
	TOTAL	325	100.0	100.0	

Mean 5.467 Std Dev 1.075 Minimum 1.000
Maximum 6.000

Valid Cases 169 Missing Cases 156

Q12.5_1 1st: not using public transport

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	73	22.5	42.9	42.9
	2	41	12.6	24.1	67.1
	3	40	12.3	23.5	90.6
	4	16	4.9	9.4	100.0
	.	155	47.7	MISSING	
	TOTAL	325	100.0	100.0	

Mean 1.994 Std Dev 1.023 Minimum 1.000
Maximum 4.000

Valid Cases 170 Missing Cases 155

G12.5_2 2nd: not using public transport

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	2	29	8.9	17.2	17.2
	3	38	11.7	22.5	39.6
	4	52	16.0	30.8	70.4
	5	50	15.4	29.6	100.0
	.	156	48.0	MISSING	
	TOTAL	325	100.0	100.0	

Mean 3.728 Std Dev 1.068 Minimum 2.000
Maximum 5.000

Valid Cases 169 Missing Cases 156

Q12.5_3 3rd: not use public transport

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	2	1	.3	.6	.6
	3	5	1.5	3.0	3.6
	4	10	3.1	6.0	9.5
	5	81	24.9	48.2	57.7
	6	71	21.8	42.3	100.0
	.	157	48.3	MISSING	

	TOTAL	325	100.0	100.0	

Mean 5.286 Std Dev .759 Minimum 2.000
Maximum 6.000

Valid Cases 168 Missing Cases 157

Q12.6 Consider using public transport

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	137	42.2	80.6	80.6
	2	33	10.2	19.4	100.0
	.	155	47.7	MISSING	
	TOTAL	325	100.0	100.0	

Mean 1.194 Std Dev .397 Minimum 1.000
Maximum 2.000

Valid Cases 170 Missing Cases 155

Q12.7 Modes considered for going to work

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	83	25.5	48.8	48.8
	2	10	3.1	5.9	54.7
	3	44	13.5	25.9	80.6
	4	33	10.2	19.4	100.0
	.	155	47.7	MISSING	
	TOTAL	325	100.0	100.0	

Mean 2.159 Std Dev 1.228 Minimum 1.000
Maximum 4.000

Valid Cases 170 Missing Cases 155

Q12.8 Distance to walk

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	122	37.5	71.8	71.8
	2	32	9.8	18.8	90.6
	3	9	2.8	5.3	95.9
	4	5	1.5	2.9	98.8
	5	2	.6	1.2	100.0

	.	155	47.7	MISSING	
		-------	-------	-------	
	TOTAL	325	100.0	100.0	

Mean 1.429 Std Dev .820 Minimum 1.000
Maximum 5.000

Valid Cases 170 Missing Cases 155

Q12.9 Waiting time for public transport

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	28	8.6	16.5	16.5
	2	74	22.8	43.5	60.0
	3	66	20.3	38.8	98.8
	4	1	.3	.6	99.4
	5	1	.3	.6	100.0
	.	155	47.7	MISSING	
		-------	-------	-------	
	TOTAL	325	100.0	100.0	

Mean 2.253 Std Dev .754 Minimum 1.000
Maximum 5.000

Valid Cases 170 Missing Cases 155

Q12.10 Nearest rail station from your home

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	3	.9	1.8	1.8
	2	4	1.2	2.4	4.1
	3	15	4.6	8.8	12.9
	4	37	11.4	21.8	34.7
	5	25	7.7	14.7	49.4
	6	86	26.5	50.6	100.0
	.	155	47.7	MISSING	
		-------	-------	-------	
	TOTAL	325	100.0	100.0	

Mean 4.971 Std Dev 1.257 Minimum 1.000
Maximum 6.000

Valid Cases 170 Missing Cases 155

Q12.11_1 1st: factor to improve rail

Valid Cum

Value Label	Value	Frequency	Percent	Percent	Percent
	1	145	44.6	85.3	85.3
	2	15	4.6	8.8	94.1
	3	4	1.2	2.4	96.5
	4	3	.9	1.8	98.2
	5	3	.9	1.8	100.0
	.	155	47.7	MISSING	
	TOTAL	325	100.0	100.0	

Mean 1.259 Std Dev .748 Minimum 1.000
Maximum 5.000

Valid Cases 170 Missing Cases 155

Q12.11_2 2nd: Factor of improvement to rail

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	2	115	35.4	69.3	69.3
	3	28	8.6	16.9	86.1
	4	19	5.8	11.4	97.6
	5	4	1.2	2.4	100.0
	.	159	48.9	MISSING	
	TOTAL	325	100.0	100.0	

Mean 2.470 Std Dev .791 Minimum 2.000
Maximum 5.000

Valid Cases 166 Missing Cases 159

Q12.11_3 3rd: Factor to improve rail

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	3	109	33.5	67.3	67.3
	4	14	4.3	8.6	75.9
	5	27	8.3	16.7	92.6
	6	12	3.7	7.4	100.0
	.	163	50.2	MISSING	
	TOTAL	325	100.0	100.0	

Mean 3.642 Std Dev 1.007 Minimum 3.000
Maximum 6.000

Valid Cases 162 Missing Cases 163

Q12.11_4 4th: Factor to improve rail

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	4	101	31.1	80.8	80.8
	5	9	2.8	7.2	88.0
	6	15	4.6	12.0	100.0
	.	200	61.5	MISSING	
	TOTAL	325	100.0	100.0	

Mean 4.312 Std Dev .677 Minimum 4.000
Maximum 6.000

Valid Cases 125 Missing Cases 200

Q12.11_5 5th: Factor to improve rail

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	5	94	28.9	97.9	97.9
	6	2	.6	2.1	100.0
	.	229	70.5	MISSING	
	TOTAL	325	100.0	100.0	

Mean 5.021 Std Dev .144 Minimum 5.000
Maximum 6.000

Valid Cases 96 Missing Cases 229

Q12.11_6 6th: Factor to improve rail

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	6	89	27.4	100.0	100.0
	.	236	72.6	MISSING	
	TOTAL	325	100.0	100.0	

Mean 6.000 Std Dev .000 Minimum 6.000
Maximum 6.000

Valid Cases 89 Missing Cases 236

Q13.1 Mode of public transport

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	102	31.4	65.8	65.8
	2	15	4.6	9.7	75.5
	3	38	11.7	24.5	100.0
	.	170	52.3	MISSING	
	TOTAL	325	100.0	100.0	

Mean 1.587 Std Dev .859 Minimum 1.000
Maximum 3.000

Valid Cases 155 Missing Cases 170

Q13.2 Time spend walking

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	73	22.5	47.1	47.1
	2	59	18.2	38.1	85.2
	3	13	4.0	8.4	93.5
	4	5	1.5	3.2	96.8
	5	5	1.5	3.2	100.0
	.	170	52.3	MISSING	
	TOTAL	325	100.0	100.0	

Mean 1.774 Std Dev .964 Minimum 1.000
Maximum 5.000

Valid Cases 155 Missing Cases 170

Q13.3 Opinion of time taken

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	1	.3	.6	.6
	2	19	5.8	12.3	12.9
	3	64	19.7	41.3	54.2
	4	56	17.2	36.1	90.3
	5	15	4.6	9.7	100.0
	.	170	52.3	MISSING	
	TOTAL	325	100.0	100.0	

Mean 3.419 Std Dev .852 Minimum 1.000
Maximum 5.000

Valid Cases 155 Missing Cases 170

Q13.4 Waiting time

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	18	5.5	11.6	11.6
	2	69	21.2	44.5	56.1
	3	40	12.3	25.8	81.9
	4	10	3.1	6.5	88.4
	5	18	5.5	11.6	100.0
	.	170	52.3	MISSING	
	TOTAL	325	100.0	100.0	

Mean 2.619 Std Dev 1.141 Minimum 1.000
Maximum 5.000

Valid Cases 155 Missing Cases 170

Q13.5 Travelling time

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	1	.3	.6	.6
	2	8	2.5	5.2	5.8
	3	45	13.8	29.0	34.8
	4	49	15.1	31.6	66.5
	5	52	16.0	33.5	100.0
	.	170	52.3	MISSING	
	TOTAL	325	100.0	100.0	

Mean 3.923 Std Dev .943 Minimum 1.000
Maximum 5.000

Valid Cases 155 Missing Cases 170

Q13.6 Time walking to work from station/stop

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	34	10.5	21.9	21.9
	2	71	21.8	45.8	67.7
	3	36	11.1	23.2	91.0
	4	8	2.5	5.2	96.1
	5	6	1.8	3.9	100.0
	.	170	52.3	MISSING	
	TOTAL	325	100.0	100.0	

Mean	2.232	Std Dev	.979	Minimum	1.000
Maximum	5.000				

Valid Cases 155 Missing Cases 170

Q13.7 Opinion of overall service provided

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	2	5	1.5	3.2	3.2
	3	51	15.7	32.9	36.1
	4	64	19.7	41.3	77.4
	5	35	10.8	22.6	100.0
	.	170	52.3	MISSING	
	TOTAL	325	100.0	100.0	

Mean	3.832	Std Dev	.812	Minimum	2.000
Maximum	5.000				

Valid Cases 155 Missing Cases 170

Q13.8 Rate the safety of transport mode

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	2	12	3.7	7.7	7.7
	3	87	26.8	56.1	63.9
	4	50	15.4	32.3	96.1
	5	6	1.8	3.9	100.0
	.	170	52.3	MISSING	
	TOTAL	325	100.0	100.0	

Mean	3.323	Std Dev	.674	Minimum	2.000
Maximum	5.000				

Valid Cases 155 Missing Cases 170

Q13.9 Adequacy of facilities/infrastructure

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	2	3	.9	1.9	1.9
	3	21	6.5	13.5	15.5
	4	51	15.7	32.9	48.4
	5	80	24.6	51.6	100.0
	.	170	52.3	MISSING	

TOTAL	325	100.0	100.0	

Mean 4.342 Std Dev .785 Minimum 2.000
Maximum 5.000

Valid Cases 155 Missing Cases 170

Q13.10_1 1st: improvement

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	1	66	20.3	42.6	42.6
	2	35	10.8	22.6	65.2
	3	33	10.2	21.3	86.5
	4	18	5.5	11.6	98.1
	5	2	.6	1.3	99.4
	6	1	.3	.6	100.0
	.	170	52.3	MISSING	
	TOTAL	325	100.0	100.0	

Mean 2.084 Std Dev 1.151 Minimum 1.000
Maximum 6.000

Valid Cases 155 Missing Cases 170

Q13.10_2 2nd improvement

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
	2	16	4.9	10.3	10.3
	3	32	9.8	20.6	31.0
	4	40	12.3	25.8	56.8
	5	52	16.0	33.5	90.3
	6	14	4.3	9.0	99.4
	7	1	.3	.6	100.0
	.	170	52.3	MISSING	
	TOTAL	325	100.0	100.0	

Mean 4.123 Std Dev 1.170 Minimum 2.000
Maximum 7.000

Valid Cases 155 Missing Cases 170

Q13.10_3 3rd: improvement

Valid Cum

Value Label	Value	Frequency	Percent	Percent	Percent
	3	5	1.5	3.3	3.3
	4	12	3.7	7.8	11.1
	5	38	11.7	24.8	35.9
	6	31	9.5	20.3	56.2
	7	67	20.6	43.8	100.0
	.	172	52.9	MISSING	
		-------	-------	-------	
	TOTAL	325	100.0	100.0	

Mean 5.935 Std Dev 1.139 Minimum 3.000
Maximum 7.000

Valid Cases 153 Missing Cases 172

This procedure was completed at 19:47:04

FINISH.

End of Include file.

APPENDIX D

Integrated Transport System : Prototype Listing

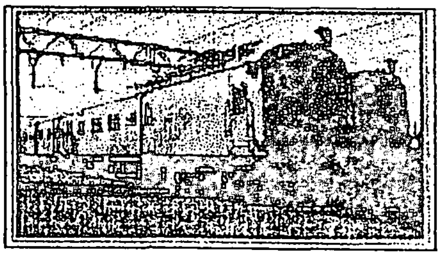
INTEGRATED TRANSPORT SYSTEM

WELCOME

Developed by Dhiren Allopi

In collaboration with Anand Govender

OK



```
VERSION 2.00
Begin Form Form1
   AutoRedraw      =   -1  'True
   Caption         =   "Screen 1"
   ClientHeight    =   5895
   ClientLeft      =   495
   ClientTop       =   1425
   ClientWidth     =   8310
   DrawMode        =   16  'Whiteness
   Height          =   6300
   Left            =   435
   LinkTopic       =   "Form1"
   ScaleHeight     =   5895
   ScaleWidth      =   8310
   Top             =   1080
   Width           =   8430
   Begin PictureBox Picture4
      Height          =   1815
      Left            =   4800
      Picture         =   (Metafile)
      ScaleHeight     =   1785
      ScaleWidth      =   3225
      TabIndex        =   8
      Top             =   3960
      Width           =   3255
   End
   Begin PictureBox Picture3
      Height          =   1815
      Left            =   240
      Picture         =   (Metafile)
      ScaleHeight     =   1785
      ScaleWidth      =   3345
      TabIndex        =   7
      Top             =   3960
      Width           =   3375
   End
   Begin PictureBox Picture2
      BorderStyle     =   0  'None
      Height          =   255
      Left            =   7080
      Picture         =   (Metafile)
      ScaleHeight     =   255
      ScaleWidth      =   855
      TabIndex        =   6
      Top             =   3480
      Width           =   855
   End
   Begin PictureBox Picture1
      AutoRedraw      =   -1  'True
      AutoSize        =   -1  'True
      BackColor       =   &H00FFFFFF&
      BorderStyle     =   0  'None
      DrawStyle       =   5  'Transparent
      Height          =   840
      Left            =   6960
      Picture         =   (Metafile)
      ScaleHeight     =   840
      ScaleWidth      =   675
      TabIndex        =   5
      Top             =   2640
```

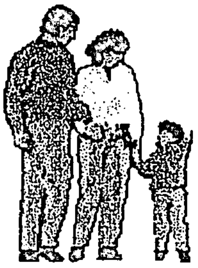
```
      Width              =   675
   End
   Begin Timer Timer1
      Interval           =   1000
      Left               =   2760
      Top                =   3240
   End
   Begin CommandButton Command1
      Caption            =   "&OK"
      Height             =   615
      Left               =   3720
      TabIndex           =   2
      Top                =   3000
      Width              =   1095
   End
   Begin Image Image2
      Height             =   480
      Left               =   5880
      Picture            =   (Icon)
      Top                =   3240
      Width              =   480
   End
   Begin Line Line4
      X1                 =   2640
      X2                 =   6360
      Y1                 =   960
      Y2                 =   960
   End
   Begin Line Line3
      X1                 =   6360
      X2                 =   6360
      Y1                 =   960
      Y2                 =   1800
   End
   Begin Line Line2
      X1                 =   2640
      X2                 =   2640
      Y1                 =   960
      Y2                 =   1800
   End
   Begin Line Line1
      X1                 =   2640
      X2                 =   6360
      Y1                 =   1800
      Y2                 =   1800
   End
   Begin Image Image1
      Height             =   480
      Left               =   5160
      Picture            =   (Icon)
      Top                =   3240
      Width              =   480
   End
   Begin Label Label5
      Alignment          =   2  'Center
      Caption            =   " In collaboration with Anand Govender"
      FontBold           =   -1  'True
      FontItalic         =   0   'False
      FontName           =   "Ribbon131 Bd BT"
      FontSize           =   18
```

```
      FontStrikethru   =   0   'False
      FontUnderline    =   0   'False
      Height           =   375
      Left             =   2280
      TabIndex         =   4
      Top              =   2520
      Width            =   4695
   End
   Begin Label Label4
      Alignment        =   2  'Center
      Caption          =   "Developed  by Dhiren Allopi"
      FontBold         =   -1  'True
      FontItalic       =   0   'False
      FontName         =   "Ribbon131 Bd BT"
      FontSize         =   18
      FontStrikethru   =   0   'False
      FontUnderline    =   0   'False
      Height           =   495
      Left             =   2520
      TabIndex         =   3
      Top              =   1920
      Width            =   4455
   End
   Begin Label Label2
      Alignment        =   2  'Center
      Caption          =   " WELCOME"
      FontBold         =   -1  'True
      FontItalic       =   0   'False
      FontName         =   "Times New Roman"
      FontSize         =   24
      FontStrikethru   =   0   'False
      FontUnderline    =   0   'False
      ForeColor        =   &H000000FF&
      Height           =   735
      Left             =   2400
      TabIndex         =   1
      Top              =   1080
      Width            =   4335
   End
   Begin Label Label1
      Alignment        =   2  'Center
      Caption          =   " INTEGRATED TRANSPORT SYSTEM"
      FontBold         =   -1  'True
      FontItalic       =   0   'False
      FontName         =   "Times New Roman"
      FontSize         =   13.5
      FontStrikethru   =   0   'False
      FontUnderline    =   0   'False
      ForeColor        =   &H00FF0000&
      Height           =   375
      Left             =   1320
      TabIndex         =   0
      Top              =   240
      Width            =   5775
   End
End
```

```
Sub Command1_Click ()
Unload form1
form2.Show
End Sub

Sub Form_Load ()
    'Center form
    Left = (Screen.Width - Width) / 2
    Top = (Screen.Height - Height) / 2

    'Place both happy faces
    Image1.Left = 1320
    Image1.Top = 1080
    Image2.Left = 1320
    Image2.Top = 1080

    'Make first face visible
    Image1.ZOrder

End Sub

Sub Timer1_Timer ()
    'Wink
    If Timer1.Interval <> 200 Then
        Timer1.Interval = 200
        Image2.ZOrder
    'Undo wink
    Else
        Timer1.Interval = 5000
        Image2.ZOrder 1
        Image1.ZOrder
    End If

End Sub
```

Application No. **100T1**

Mode of transport?



TRAIN ONLY

TRAIN AND TAXI

Back

```
VERSION 2.00
Begin Form Form2
   AutoRedraw      =   -1  'True
   Caption         =   "Screen 2"
   ClientHeight    =   4020
   ClientLeft      =   1500
   ClientTop       =   1335
   ClientWidth     =   5880
   Height          =   4425
   Left            =   1440
   LinkTopic       =   "Form2"
   ScaleHeight     =   4020
   ScaleWidth      =   5880
   Top             =   990
   Width           =   6000
   Begin PictureBox Picture1
      BorderStyle     =   0  'None
      Height          =   1935
      Left            =   1440
      Picture         =   (Metafile)
      ScaleHeight     =   1935
      ScaleWidth      =   1455
      TabIndex        =   6
      Top             =   1320
      Width           =   1455
   End
   Begin CommandButton Command3
      Caption         =   " &Back"
      Height          =   495
      Left            =   2400
      TabIndex        =   5
      Top             =   3360
      Width           =   1095
   End
   Begin CommandButton Command2
      Caption         =   " TRAIN &AND TAXI"
      Height          =   615
      Left            =   3480
      TabIndex        =   3
      Top             =   2520
      Width           =   1695
   End
   Begin CommandButton Command1
      Caption         =   " TRAIN &ONLY"
      Default         =   -1  'True
      Height          =   615
      Left            =   3480
      TabIndex        =   2
      Top             =   1560
      Width           =   1695
   End
   Begin TextBox Text1
      Alignment       =   2  'Center
      FontBold        =   -1  'True
      FontItalic      =   0   'False
      FontName        =   "Times New Roman"
      FontSize        =   13.5
      FontStrikethru  =   0   'False
      FontUnderline   =   0   'False
      Height          =   480
```

```
      Left              =   2520
      TabIndex          =   1
      Text              =   " 100T1"
      Top               =   0
      Width             =   975
   End
   Begin Label Label2
      Alignment         =   2  'Center
      Caption           =   " Mode of transport?"
      FontBold          =   -1  'True
      FontItalic        =   0   'False
      FontName          =   "Times New Roman"
      FontSize          =   13.5
      FontStrikethru    =   0   'False
      FontUnderline     =   0   'False
      Height            =   375
      Left              =   960
      TabIndex          =   4
      Top               =   960
      Width             =   3615
   End
   Begin Label Label1
      Caption           =   " Application No."
      FontBold          =   -1  'True
      FontItalic        =   0   'False
      FontName          =   "Times New Roman"
      FontSize          =   13.5
      FontStrikethru    =   0   'False
      FontUnderline     =   0   'False
      ForeColor         =   &H00800080&
      Height            =   375
      Left              =   120
      TabIndex          =   0
      Top               =   0
      Width             =   2055
   End
End
```

SCREEN2.FRM - 1

```
Sub Command2_Click ()
Unload form2
form3.Show

End Sub

Sub Command3_Click ()
Unload form2
form1.Show
End Sub
```

Application No. 100T1

Type of Ticket

- ○ Single Trip Ticket
- ○ Return Trip Ticket
- ○ Weekly Ticket
- ○ Monthly Ticket
- ○ Quarterly Ticket
- ○ Yearly Ticket

```
VERSION 2.00
Begin Form Form3
   AutoRedraw      =   -1  'True
   Caption         =   "Screen 3"
   ClientHeight    =   4020
   ClientLeft      =   1590
   ClientTop       =   1635
   ClientWidth     =   5835
   Height          =   4425
   Left            =   1530
   LinkTopic       =   "Form3"
   ScaleHeight     =   4020
   ScaleWidth      =   5835
   Top             =   1290
   Width           =   5955
   Begin Frame Frame1
      Caption         =   " Type of Ticket"
      Height          =   2655
      Left            =   1080
      TabIndex        =   3
      Top             =   720
      Width           =   3615
      Begin OptionButton Option6
         Caption         =   " Yearly Ticket"
         Height          =   375
         Left            =   240
         TabIndex        =   9
         Top             =   2160
         Width           =   3255
      End
      Begin OptionButton Option5
         Caption         =   "Quarterly Ticket"
         Height          =   375
         Left            =   240
         TabIndex        =   8
         Top             =   1800
         Width           =   3255
      End
      Begin OptionButton Option4
         Caption         =   " Monthly Ticket"
         Height          =   375
         Left            =   240
         TabIndex        =   7
         Top             =   1440
         Width           =   3255
      End
      Begin OptionButton Option3
         Caption         =   " Weekly Ticket"
         Height          =   375
         Left            =   240
         TabIndex        =   6
         Top             =   1080
         Width           =   3255
      End
      Begin OptionButton Option2
         Caption         =   " Return Trip Ticket"
         Height          =   375
         Left            =   240
         TabIndex        =   5
         Top             =   720
```

```
         Width             =   3255
      End
      Begin OptionButton Option1
         Caption           =   " Single Trip Ticket"
         Height            =   375
         Left              =   240
         TabIndex          =   4
         Top               =   360
         Width             =   3255
      End
   End
   Begin TextBox Text1
      Alignment         =   2  'Center
      FontBold          =   -1  'True
      FontItalic        =   0   'False
      FontName          =   "Times New Roman"
      FontSize          =   13.5
      FontStrikethru    =   0   'False
      FontUnderline     =   0   'False
      Height            =   480
      Left              =   2400
      TabIndex          =   2
      Text              =   " 100T1"
      Top               =   0
      Width             =   975
   End
   Begin Label Label1
      Caption           =   " Application No."
      FontBold          =   -1  'True
      FontItalic        =   0   'False
      FontName          =   "Times New Roman"
      FontSize          =   13.5
      FontStrikethru    =   0   'False
      FontUnderline     =   0   'False
      ForeColor         =   &H00800080&
      Height            =   375
      Index             =   1
      Left              =   0
      TabIndex          =   1
      Top               =   0
      Width             =   2055
   End
   Begin Label Label1
      Caption           =   "Label1"
      Height            =   375
      Index             =   0
      Left              =   240
      TabIndex          =   0
      Top               =   0
      Width             =   1815
   End
End
```

```
Sub Option1_Click ()
Unload form3
form4.Show
End Sub

Sub Option2_Click ()
Unload form3
form4.Show
End Sub

Sub Option3_Click ()
Unload form3
form4.Show
End Sub
```

Application No. 100T1 Back

Boarding	Destination
(•) Bayview	( ) Bayview
( ) Berea	( ) Berea
( ) Chatsglen	( ) Chatsglen
( ) Clairwood	( ) Clairwood
( ) Congella	( ) Congella
( ) Crossmoor	( ) Crossmoor
( ) Dalbridge	( ) Dalbridge
( ) Durban	( ) Durban
( ) Havenside	( ) Havenside
( ) Merebank	( ) Merebank
( ) Montclair	( ) Montclair
( ) Rossburgh	( ) Rossburgh
( ) Umbilo	( ) Umbilo
( ) Westcliff	( ) Westcliff

```
VERSION 2.00
Begin Form Form4
   AutoRedraw      =   -1  'True
   Caption         =   "Screen 4"
   ClientHeight    =   4140
   ClientLeft      =   1500
   ClientTop       =   1590
   ClientWidth     =   5790
   Height          =   4545
   Left            =   1440
   LinkTopic       =   "Form4"
   ScaleHeight     =   4140
   ScaleWidth      =   5790
   Top             =   1245
   Width           =   5910
   Begin CommandButton Command1
      Caption         =   " &Back"
      Height          =   375
      Left            =   4320
      TabIndex        =   32
      Top             =   120
      Width           =   1335
   End
   Begin Frame Frame1
      Caption         =   " Destination"
      Height          =   3615
      Index           =   1
      Left            =   3000
      TabIndex        =   3
      Top             =   480
      Width           =   2655
      Begin OptionButton Option14
         Caption         =   " Westcliff"
         Height          =   195
         Index           =   1
         Left            =   120
         TabIndex        =   31
         Top             =   3360
         Width           =   1575
      End
      Begin OptionButton Option13
         Caption         =   " Umbilo"
         Height          =   195
         Index           =   1
         Left            =   120
         TabIndex        =   30
         Top             =   3120
         Width           =   1935
      End
      Begin OptionButton Option12
         Caption         =   " Rossburgh"
         Height          =   195
         Index           =   1
         Left            =   120
         TabIndex        =   29
         Top             =   2880
         Width           =   2295
      End
      Begin OptionButton Option11
         Caption         =   " Montclair"
```

```
         Height          =   255
         Index           =   1
         Left            =   120
         TabIndex        =   28
         Top             =   2640
         Width           =   2295
      End
      Begin OptionButton Option10
         Caption         =   " Merebank"
         Height          =   195
         Index           =   1
         Left            =   120
         TabIndex        =   27
         Top             =   2400
         Width           =   2295
      End
      Begin OptionButton Option9
         Caption         =   " Havenside"
         Height          =   255
         Index           =   1
         Left            =   120
         TabIndex        =   26
         Top             =   2160
         Width           =   2295
      End
      Begin OptionButton Option8
         Caption         =   " Durban"
         Height          =   195
         Index           =   1
         Left            =   120
         TabIndex        =   25
         Top             =   1920
         Width           =   2295
      End
      Begin OptionButton Option7
         Caption         =   " Dalbridge"
         Height          =   195
         Index           =   1
         Left            =   120
         TabIndex        =   24
         Top             =   1680
         Width           =   2295
      End
      Begin OptionButton Option6
         Caption         =   " Crossmoor"
         Height          =   195
         Index           =   1
         Left            =   120
         TabIndex        =   23
         Top             =   1440
         Width           =   2295
      End
      Begin OptionButton Option5
         Caption         =   " Congella"
         Height          =   255
         Index           =   1
         Left            =   120
         TabIndex        =   22
         Top             =   1200
         Width           =   2295
```

```
      End
      Begin OptionButton Option4
         Caption         =   " Clairwood"
         Height          =   195
         Index           =   1
         Left            =   120
         TabIndex        =   21
         Top             =   960
         Width           =   2295
      End
      Begin OptionButton Option3
         Caption         =   " Chatsglen"
         Height          =   255
         Index           =   1
         Left            =   120
         TabIndex        =   20
         Top             =   720
         Width           =   2295
      End
      Begin OptionButton Option2
         Caption         =   " Berea"
         Height          =   195
         Index           =   1
         Left            =   120
         TabIndex        =   19
         Top             =   480
         Width           =   2295
      End
      Begin OptionButton Option1
         Caption         =   " Bayview"
         Height          =   195
         Index           =   1
         Left            =   120
         TabIndex        =   18
         Top             =   240
         Width           =   2295
      End
   End
   Begin Frame Frame1
      Caption         =   " Boarding"
      Height          =   3615
      Index           =   0
      Left            =   240
      TabIndex        =   2
      Top             =   480
      Width           =   2655
      Begin OptionButton Option14
         Caption         =   " Westcliff"
         Height          =   195
         Index           =   0
         Left            =   240
         TabIndex        =   17
         Top             =   3360
         Width           =   1575
      End
      Begin OptionButton Option13
         Caption         =   " Umbilo"
         Height          =   195
         Index           =   0
         Left            =   240
```

```
         TabIndex        =   16
         Top             =   3120
         Width           =   1935
      End
      Begin OptionButton Option12
         Caption         =   " Rossburgh"
         Height          =   195
         Index           =   0
         Left            =   240
         TabIndex        =   15
         Top             =   2880
         Width           =   2295
      End
      Begin OptionButton Option11
         Caption         =   " Montclair"
         Height          =   255
         Index           =   0
         Left            =   240
         TabIndex        =   14
         Top             =   2640
         Width           =   2295
      End
      Begin OptionButton Option10
         Caption         =   " Merebank"
         Height          =   195
         Index           =   0
         Left            =   240
         TabIndex        =   13
         Top             =   2400
         Width           =   2295
      End
      Begin OptionButton Option9
         Caption         =   " Havenside"
         Height          =   195
         Index           =   0
         Left            =   240
         TabIndex        =   12
         Top             =   2160
         Width           =   2295
      End
      Begin OptionButton Option8
         Caption         =   " Durban"
         Height          =   195
         Index           =   0
         Left            =   240
         TabIndex        =   11
         Top             =   1920
         Width           =   2295
      End
      Begin OptionButton Option7
         Caption         =   " Dalbridge"
         Height          =   195
         Index           =   0
         Left            =   240
         TabIndex        =   10
         Top             =   1680
         Width           =   2295
      End
      Begin OptionButton Option6
         Caption         =   " Crossmoor"
```

```
         Height          =   195
         Index           =   0
         Left            =   240
         TabIndex        =   9
         Top             =   1440
         Width           =   2295
      End
      Begin OptionButton Option5
         Caption         =   " Congella"
         Height          =   255
         Index           =   0
         Left            =   240
         TabIndex        =   8
         Top             =   1200
         Width           =   2295
      End
      Begin OptionButton Option4
         Caption         =   " Clairwood"
         Height          =   195
         Index           =   0
         Left            =   240
         TabIndex        =   7
         Top             =   960
         Width           =   2295
      End
      Begin OptionButton Option3
         Caption         =   " Chatsglen"
         Height          =   255
         Index           =   0
         Left            =   240
         TabIndex        =   6
         Top             =   720
         Width           =   2295
      End
      Begin OptionButton Option2
         Caption         =   " Berea"
         Height          =   195
         Index           =   0
         Left            =   240
         TabIndex        =   5
         Top             =   480
         Width           =   2295
      End
      Begin OptionButton Option1
         Caption         =   " Bayview"
         Height          =   195
         Index           =   0
         Left            =   240
         TabIndex        =   4
         Top             =   240
         Value           =   -1  'True
         Width           =   2295
      End
   End
   Begin TextBox Text1
      Alignment       =   2  'Center
      FontBold        =   -1  'True
      FontItalic      =   0   'False
      FontName        =   "Times New Roman"
      FontSize        =   13.5
```

```
      FontStrikethru  =   0   'False
      FontUnderline   =   0   'False
      Height          =   480
      Left            =   2280
      TabIndex        =   1
      Text            =   " 100T1"
      Top             =   0
      Width           =   975
   End
   Begin Label Label1
      Caption         =   " Application No."
      FontBold        =   -1  'True
      FontItalic      =   0   'False
      FontName        =   "Times New Roman"
      FontSize        =   13.5
      FontStrikethru  =   0   'False
      FontUnderline   =   0   'False
      ForeColor       =   &H00800080&
      Height          =   375
      Index           =   1
      Left            =   0
      TabIndex        =   0
      Top             =   0
      Width           =   2055
   End
End
```

```
Sub Combo1_Change ()

End Sub

Sub Command1_Click ()     ' Delete text.
Unload form4
form3.Show

End Sub

Sub Option10_Click (Index As Integer)
Unload form4
form5.Show
End Sub

Sub Option3_Click (Index As Integer)
Unload form4
form5.Show
End Sub

Sub Option4_Click (Index As Integer)
Unload form4
form6.Show
End Sub

Sub Option6_Click (Index As Integer)
Unload form4
form7.Show
End Sub

Sub Option8_Click (Index As Integer)
Unload form4
form7.Show
End Sub
```

Application No. **100T1**

Boarding: Bayview

Destination: Merebank

The Cost of a Single Trip is: R5.00

The Departure times for the train from: Bayview

Date: 02:03:98

Print Ticket

Print Schedule

Back

TRAIN TIMES

TAXI ROUTES

TAXI TIMES

```
VERSION 2.00
Begin Form Form5
   Caption         =   " Screen 5"
   ClientHeight    =   3615
   ClientLeft      =   1710
   ClientTop       =   1980
   ClientWidth     =   5895
   Height          =   4020
   Left            =   1650
   LinkTopic       =   "Form5"
   ScaleHeight     =   3615
   ScaleWidth      =   5895
   Top             =   1635
   Width           =   6015
   Begin ComboBox Combo3
      Height          =   315
      Left            =   3840
      TabIndex        =   16
      Text            =   "TRAIN TIMES"
      Top             =   2640
      Width           =   1575
   End
   Begin ComboBox Combo2
      Height          =   315
      Left            =   3840
      TabIndex        =   17
      Text            =   "TAXI TIMES"
      Top             =   3120
      Width           =   1575
   End
   Begin ComboBox Combo1
      Height          =   315
      Left            =   480
      TabIndex        =   18
      Text            =   " TAXI ROUTES"
      Top             =   3120
      Width           =   1935
   End
   Begin CommandButton Command3
      Caption         =   " &Back"
      Height          =   495
      Left            =   4440
      TabIndex        =   15
      Top             =   1560
      Width           =   1335
   End
   Begin CommandButton Command2
      Caption         =   " Print &Schedule"
      Height          =   495
      Left            =   4440
      TabIndex        =   14
      Top             =   960
      Width           =   1335
   End
   Begin CommandButton Command1
      Caption         =   "Print &Ticket"
      Height          =   495
      Left            =   4440
      TabIndex        =   13
      Top             =   360
```

```
      Width              =   1335
   End
   Begin TextBox Text4
      Height             =   375
      Left               =   1320
      TabIndex           =   11
      Text               =   " 02:03:98"
      Top                =   2640
      Width              =   975
   End
   Begin TextBox Text2
      Height             =   375
      Index              =   2
      Left               =   2040
      TabIndex           =   9
      Text               =   " Bayview"
      Top                =   2160
      Width              =   2535
   End
   Begin TextBox Text3
      Height             =   375
      Left               =   3000
      TabIndex           =   7
      Text               =   " R5.00"
      Top                =   1440
      Width              =   1335
   End
   Begin TextBox Text2
      Height             =   375
      Index              =   1
      Left               =   1560
      TabIndex           =   5
      Text               =   " Merebank"
      Top                =   960
      Width              =   2535
   End
   Begin TextBox Text2
      Height             =   375
      Index              =   0
      Left               =   1560
      TabIndex           =   4
      Text               =   " Bayview"
      Top                =   480
      Width              =   2535
   End
   Begin TextBox Text1
      Alignment          =   2  'Center
      FontBold           =   -1  'True
      FontItalic         =   0   'False
      FontName           =   "Times New Roman"
      FontSize           =   13.5
      FontStrikethru     =   0   'False
      FontUnderline      =   0   'False
      Height             =   480
      Left               =   2400
      TabIndex           =   1
      Text               =   " 100T1"
      Top                =   0
      Width              =   975
   End
```

```
   Begin Label Label1
      Caption         =   " Application No."
      FontBold        =   -1  'True
      FontItalic      =   0   'False
      FontName        =   "Times New Roman"
      FontSize        =   13.5
      FontStrikethru  =   0   'False
      FontUnderline   =   0   'False
      ForeColor       =   &H00800080&
      Height          =   375
      Index           =   0
      Left            =   0
      TabIndex        =   19
      Top             =   0
      Width           =   2055
   End
   Begin Label Label7
      Caption         =   " "
      Height          =   255
      Index           =   0
      Left            =   3480
      TabIndex        =   12
      Top             =   2760
      Width           =   615
   End
   Begin Label Label6
      Caption         =   " Date:"
      Height          =   255
      Left            =   480
      TabIndex        =   10
      Top             =   2760
      Width           =   735
   End
   Begin Label Label5
      Caption         =   " The Departure times for the train from:"
      Height          =   375
      Left            =   360
      TabIndex        =   8
      Top             =   1920
      Width           =   3615
   End
   Begin Label Label4
      Caption         =   " The Cost of a Single Trip is:"
      Height          =   375
      Left            =   360
      TabIndex        =   6
      Top             =   1440
      Width           =   2655
   End
   Begin Label Label3
      Caption         =   " Destination:"
      Height          =   255
      Left            =   120
      TabIndex        =   3
      Top             =   960
      Width           =   1215
   End
   Begin Label Label2
      Caption         =   " Boarding:"
      Height          =   255
```

```
      Left             =   120
      TabIndex         =   2
      Top              =   480
      Width            =   1095
   End
   Begin Label Label1
      Caption          =   " Application No."
      FontBold         =   -1  'True
      FontItalic       =   0   'False
      FontName         =   "Times New Roman"
      FontSize         =   13.5
      FontStrikethru   =   0   'False
      FontUnderline    =   0   'False
      ForeColor        =   &H00800080&
      Height           =   375
      Index            =   1
      Left             =   0
      TabIndex         =   0
      Top              =   0
      Width            =   2055
   End
End
```

```
Sub Combo1_Click ()
  Dim entry1, entry2



End Sub

Sub Command1_Click ()
Unload form5
form9.Show
End Sub

Sub Command2_Click ()
Unload form5
form11.Show
End Sub

Sub Command3_Click ()
Unload form5
form4.Show
End Sub

Sub Form_Load ()
Dim entry1, entry2, entry3, entry4, entry5, entry6, entry7, entry8
entry1 = "15:00"
combo3.AddItem entry1
entry2 = "16:00"
combo3.AddItem entry2
entry3 = "17:00"
combo3.AddItem entry3
entry4 = "Pelican/Turnstone"
combo1.AddItem entry4
entry5 = "Pelican/Skylark"
combo1.AddItem entry5
entry6 = "Pelican/Liberty"
combo1.AddItem entry6
entry1 = "14:55"
combo2.AddItem entry1
entry2 = "15:55"
combo2.AddItem entry2
entry3 = "16:55"
combo2.AddItem entry3

End Sub
```

INTEGRATED TRANSPORT SERVICE

Application No. 100T1 Date: 02:03:98

Boarding: Bayview

Destination: Merebank

Taxi Stop: Pelican/Turnstone

TAXI
Depart

SINGLE Ticket

TRAIN
Depart

Have a safe journey!

Cost: R5.00

Amount Paid: R20.00

Change: R15.00

Back Print

```
VERSION 2.00
Begin Form Form9
   Caption         =   " Screen 9"
   ClientHeight    =   4485
   ClientLeft      =   2130
   ClientTop       =   2550
   ClientWidth     =   5070
   Height          =   4890
   Left            =   2070
   LinkTopic       =   "Form9"
   ScaleHeight     =   4485
   ScaleWidth      =   5070
   Top             =   2205
   Width           =   5190
   Begin CommandButton Command2
      Caption         =   " &Print"
      Height          =   375
      Left            =   3600
      TabIndex        =   24
      Top             =   3960
      Width           =   1215
   End
   Begin TextBox Text8
      Height          =   375
      Left            =   1680
      TabIndex        =   23
      Text            =   " Pelican/Turnstone"
      Top             =   1560
      Width           =   1815
   End
   Begin CommandButton Command1
      Caption         =   " &Back"
      Height          =   375
      Left            =   2160
      TabIndex        =   22
      Top             =   3960
      Width           =   1215
   End
   Begin TextBox Text7
      Height          =   285
      Left            =   4080
      TabIndex        =   21
      Text            =   " R15.00"
      Top             =   3600
      Width           =   975
   End
   Begin TextBox Text6
      Height          =   285
      Left            =   4080
      TabIndex        =   19
      Text            =   " R20.00"
      Top             =   3240
      Width           =   975
   End
   Begin TextBox Text2
      Height          =   375
```

```
      Left              =   960
      TabIndex          =   17
      Text              =   " R5.00"
      Top               =   3360
      Width             =   1095
   End
   Begin Frame Frame2
      Caption           =   " TRAIN"
      Height            =   735
      Left              =   3240
      TabIndex          =   11
      Top               =   2160
      Width             =   1575
      Begin OptionButton Option1
         Caption           =   " Depart"
         Height            =   375
         Index             =   1
         Left              =   120
         TabIndex          =   12
         Top               =   240
         Width             =   1335
      End
   End
   Begin Frame Frame1
      Caption           =   " TAXI"
      Height            =   735
      Left              =   120
      TabIndex          =   9
      Top               =   2160
      Width             =   1575
      Begin OptionButton Option1
         Caption           =   " Depart"
         Height            =   375
         Index             =   0
         Left              =   120
         TabIndex          =   10
         Top               =   240
         Width             =   1335
      End
   End
   Begin TextBox Text5
      Height            =   375
      Left              =   3000
      TabIndex          =   8
      Text              =   " Merebank"
      Top               =   1080
      Width             =   1935
   End
   Begin TextBox Text4
      Height            =   375
      Left              =   120
      TabIndex          =   6
      Text              =   " Bayview"
      Top               =   1080
      Width             =   1815
   End
```

```
   Begin TextBox Text3
      Height          =   375
      Left            =   4080
      TabIndex        =   4
      Text            =   " 02:03:98"
      Top             =   360
      Width           =   975
   End
   Begin TextBox Text1
      Alignment       =   2  'Center
      FontBold        =   -1  'True
      FontItalic      =   0   'False
      FontName        =   "Times New Roman"
      FontSize        =   13.5
      FontStrikethru  =   0   'False
      FontUnderline   =   0   'False
      Height          =   480
      Left            =   2280
      TabIndex        =   2
      Text            =   " 100T1"
      Top             =   360
      Width           =   975
   End
   Begin Label Label11
      Caption         =   " Taxi Stop:"
      Height          =   255
      Left            =   600
      TabIndex        =   25
      Top             =   1560
      Width           =   975
   End
   Begin Label Label9
      Caption         =   " Change:"
      Height          =   255
      Left            =   3120
      TabIndex        =   20
      Top             =   3600
      Width           =   855
   End
   Begin Label Label8
      Caption         =   " Amount Paid:"
      Height          =   255
      Left            =   2760
      TabIndex        =   18
      Top             =   3240
      Width           =   1335
   End
   Begin Label Label3
      Caption         =   " Cost:"
      Height          =   255
      Left            =   240
      TabIndex        =   16
      Top             =   3360
      Width           =   615
   End
   Begin Label Label10
```

```
      Caption          =   " Have a safe journey!"
      FontBold         =   -1  'True
      FontItalic       =   -1  'True
      FontName         =   "Times New Roman"
      FontSize         =   12
      FontStrikethru   =   0   'False
      FontUnderline    =   0   'False
      Height           =   375
      Left             =   1320
      TabIndex         =   15
      Top              =   2880
      Width            =   2295
   End
   Begin Label Label7
      Alignment        =   2  'Center
      Caption          =   "Ticket"
      FontBold         =   -1  'True
      FontItalic       =   0   'False
      FontName         =   "Times New Roman"
      FontSize         =   13.5
      FontStrikethru   =   0   'False
      FontUnderline    =   -1  'True
      Height           =   375
      Left             =   1800
      TabIndex         =   14
      Top              =   2520
      Width            =   1215
   End
   Begin Label Label2
      Alignment        =   2  'Center
      Caption          =   "SINGLE"
      FontBold         =   -1  'True
      FontItalic       =   0   'False
      FontName         =   "Times New Roman"
      FontSize         =   13.5
      FontStrikethru   =   0   'False
      FontUnderline    =   -1  'True
      Height           =   375
      Left             =   1800
      TabIndex         =   13
      Top              =   2160
      Width            =   1335
   End
   Begin Label Label6
      Caption          =   " Destination"
      Height           =   375
      Left             =   3360
      TabIndex         =   7
      Top              =   840
      Width            =   1455
   End
   Begin Label Label5
      Caption          =   " Boarding"
      Height           =   255
      Left             =   360
      TabIndex         =   5
```

```
      Top               =   840
      Width             =   1455
   End
   Begin Label Label4
      Caption           =   " Date:"
      Height            =   375
      Left              =   3360
      TabIndex          =   3
      Top               =   360
      Width             =   615
   End
   Begin Label Label1
      Caption           =   " Application No."
      FontBold          =   -1  'True
      FontItalic        =   0   'False
      FontName          =   "Times New Roman"
      FontSize          =   13.5
      FontStrikethru    =   0   'False
      FontUnderline     =   0   'False
      ForeColor         =   &H00800080&
      Height            =   375
      Index             =   1
      Left              =   0
      TabIndex          =   1
      Top               =   360
      Width             =   2055
   End
   Begin Label Label1
      Alignment         =   2  'Center
      Caption           =   " INTEGRATED TRANSPORT SERVICE"
      FontBold          =   -1  'True
      FontItalic        =   0   'False
      FontName          =   "Times New Roman"
      FontSize          =   12
      FontStrikethru    =   0   'False
      FontUnderline     =   0   'False
      Height            =   375
      Index             =   0
      Left              =   360
      TabIndex          =   0
      Top               =   0
      Width             =   4335
   End
End
```

```
Sub Command1_Click ()
Unload form9
form5.Show
End Sub

Sub Command2_Click ()
PrintForm
End Sub
```

Application No. 100T1 Date: 02:03:98

Boarding: Bayview Destination: Merebank

SCHEDULE

TAXI	TRAIN
Arrival: 14:50 Depart: 14:55	Arrival: 14:55 Depart: 15:00
Arrival: 15:50 Depart: 15:55	Arrival: 15:55 Depart: 16:00
Arrival: 16:50 Depart: 16:55	Arrival: 16:55 Depart: 17:00
Arrival: 17:50 Depart: 17:55	Arrival: 17:55 Depart: 18:00
Arrival: 18:50 Depart: 18:55	Arrival: 18:55 Depart: 19:00

Taxi Stop

Pelican/Turnstone

Back Print

```
VERSION 2.00
Begin Form Form11
   Caption         =   " Screen 11"
   ClientHeight    =   4650
   ClientLeft      =   1620
   ClientTop       =   1380
   ClientWidth     =   5835
   Height          =   5055
   Left            =   1560
   LinkTopic       =   "Form11"
   ScaleHeight     =   4650
   ScaleWidth      =   5835
   Top             =   1035
   Width           =   5955
   Begin CommandButton Command2
      Caption         =   " &Print"
      Height          =   375
      Left            =   3840
      TabIndex        =   23
      Top             =   4200
      Width           =   1215
   End
   Begin CommandButton Command1
      Caption         =   " &Back"
      Height          =   375
      Left            =   2400
      TabIndex        =   22
      Top             =   4200
      Width           =   1215
   End
   Begin TextBox Text14
      Height          =   375
      Left            =   240
      TabIndex        =   21
      Text            =   " Pelican/Turnstone"
      Top             =   4200
      Width           =   1815
   End
   Begin Frame Frame2
      Caption         =   " TRAIN"
      Height          =   2415
      Left            =   3000
      TabIndex        =   15
      Top             =   1440
      Width           =   2775
      Begin TextBox Text13
         Height          =   285
         Left            =   120
         TabIndex        =   20
         Text            =   " Arrival: 14:55 Depart: 15:00"
         Top             =   360
         Width           =   2535
      End
      Begin TextBox Text12
         Height          =   285
         Left            =   120
```

```
         TabIndex        =   19
         Text            =   " Arrival: 15:55 Depart: 16:00"
         Top             =   720
         Width           =   2535
      End
      Begin TextBox Text11
         Height          =   285
         Left            =   120
         TabIndex        =   18
         Text            =   " Arrival: 16:55 Depart: 17:00"
         Top             =   1080
         Width           =   2535
      End
      Begin TextBox Text10
         Height          =   285
         Left            =   120
         TabIndex        =   17
         Text            =   " Arrival: 17:55 Depart: 18:00"
         Top             =   1440
         Width           =   2535
      End
      Begin TextBox Text9
         Height          =   285
         Left            =   120
         TabIndex        =   16
         Text            =   " Arrival: 18:55 Depart: 19:00"
         Top             =   1800
         Width           =   2535
      End
   End
   Begin Frame Frame1
      Caption         =   " TAXI"
      Height          =   2415
      Left            =   120
      TabIndex        =   9
      Top             =   1440
      Width           =   2775
      Begin TextBox Text8
         Height          =   285
         Left            =   120
         TabIndex        =   14
         Text            =   " Arrival: 18:50 Depart: 18:55"
         Top             =   1800
         Width           =   2535
      End
      Begin TextBox Text7
         Height          =   285
         Left            =   120
         TabIndex        =   13
         Text            =   " Arrival: 17:50 Depart: 17:55"
         Top             =   1440
         Width           =   2535
      End
      Begin TextBox Text6
         Height          =   285
         Left            =   120
```

```
            TabIndex        =   12
            Text            =   " Arrival: 16:50 Depart: 16:55"
            Top             =   1080
            Width           =   2535
         End
         Begin TextBox Text5
            Height          =   285
            Left            =   120
            TabIndex        =   11
            Text            =   " Arrival: 15:50 Depart: 15:55"
            Top             =   720
            Width           =   2535
         End
         Begin TextBox Text4
            Height          =   285
            Left            =   120
            TabIndex        =   10
            Text            =   " Arrival: 14:50 Depart: 14:55"
            Top             =   360
            Width           =   2535
         End
      End
      Begin TextBox Text3
         Height          =   375
         Left            =   4680
         TabIndex        =   7
         Text            =   " 02:03:98"
         Top             =   0
         Width           =   1095
      End
      Begin TextBox Text2
         Height          =   375
         Index           =   1
         Left            =   4080
         TabIndex        =   5
         Text            =   " Merebank"
         Top             =   480
         Width           =   1455
      End
      Begin TextBox Text2
         Height          =   375
         Index           =   0
         Left            =   1080
         TabIndex        =   3
         Text            =   " Bayview"
         Top             =   480
         Width           =   1575
      End
      Begin TextBox Text1
         Alignment       =   2  'Center
         FontBold        =   -1  'True
         FontItalic      =   0   'False
         FontName        =   "Times New Roman"
         FontSize        =   13.5
         FontStrikethru  =   0   'False
         FontUnderline   =   0   'False
```

```
      Height            =    480
      Left              =    2400
      TabIndex          =    1
      Text              =    " 100T1"
      Top               =    0
      Width             =    975
   End
   Begin Label Label6
      Caption           =    " Taxi Stop"
      Height            =    255
      Left              =    600
      TabIndex          =    24
      Top               =    3960
      Width             =    1455
   End
   Begin Label Label5
      Caption           =    " SCHEDULE"
      FontBold          =    -1  'True
      FontItalic        =    -1  'True
      FontName          =    "Times New Roman"
      FontSize          =    18
      FontStrikethru    =    0   'False
      FontUnderline     =    0   'False
      Height            =    495
      Left              =    2040
      TabIndex          =    8
      Top               =    960
      Width             =    2055
   End
   Begin Label Label4
      Caption           =    " Date:"
      Height            =    255
      Left              =    3840
      TabIndex          =    6
      Top               =    0
      Width             =    615
   End
   Begin Label Label3
      Caption           =    " Destination:"
      Height            =    255
      Left              =    2760
      TabIndex          =    4
      Top               =    480
      Width             =    1215
   End
   Begin Label Label2
      Caption           =    " Boarding:"
      Height            =    255
      Left              =    0
      TabIndex          =    2
      Top               =    480
      Width             =    1095
   End
   Begin Label Label1
      Caption           =    " Application No."
      FontBold          =    -1  'True
```

```
      FontItalic        =   0    'False
      FontName          =   "Times New Roman"
      FontSize          =   13.5
      FontStrikethru    =   0    'False
      FontUnderline     =   0    'False
      ForeColor         =   &H00800080&
      Height            =   375
      Index             =   1
      Left              =   0
      TabIndex          =   0
      Top               =   0
      Width             =   2055
   End
End
```

```
Sub Command1_Click ()
Unload form11
form5.Show
End Sub

Sub Command2_Click ()
PrintForm
End Sub
```

APPENDIX E

Conference Presentations and Publications based on the Thesis

Annexure E

Conference Presentations and Publications based on the Thesis

1. Allopi D & Sarkar A.K.; Increasing the utility of existing transportation infrastructure: a case study. *Paper presented at the Third International Conference of the Third World Science, Technology and Development.* Pietermaritzburg, South Africa, 1996.

2. Allopi D & Sarkar A.K.; Assessment on the current transport situation and its impacts on commuter perceptions: a case study. *Presented and published in the proceedings of the South African Transport Conference: Vol. 4B.* Johannesburg, South Africa, 1997.

3. Allopi D & Sarkar A.K; Commuter perceptions on private and public transport modes: a case study. *Presented and published in the proceedings of the Third International Conference on Urban Transport and the Environment for the 21st Century.* Computational Mechanics, Southhampton, UK, 1997.

The following paper was accepted for publication and presentation at the CODATU VIII International Conference which will be held in September 1998 in the Cape:

1. Allopi D & Sarkar A.K.; Making public transport effective: a case study. *Proceedings of the 8th International Conference of the Cooperation for the continuing development of urban and suburban transportation.* Balkema, Rotterdam, Netherlands, 1998.

The following paper has been submitted for possible publication in the African Journal of Science and Technology by UNESCO Nairobi office:

1. Allopi D & Sarkar A. K. ; Towards an Effective and Efficient Rail Transport System: A Case Study.

SCIENCE and TECHNOLOGY in RECONSTRUCTION and DEVELOPMENT
UNIVERSITY OF NATAL
Pietermaritzburg
SOUTH AFRICA
23-26 September, 1996.

Professor Ahmed C Bawa, Vice Principal, University of Natal. Private Bag X01, Scottsville 3209, Pietermaritzburg, South Africa. Phone: 0331 260 5975, Fax: 0331 260 5788. e-mail: bawa@exec.unp.ac.za

Dr Dipak Ghosh, Department of Economics, University of Stirling. Stirling. FK9 4LA. Scotland, UK. Phone : 01786 467479, Fax: 01786 467469 email : dipak.ghosh@stir.a c.uk

2 August 1996

Mr D. Allopi
Department of Civil Engineering and Surveying
ML Sultan Technikon
PO Box 1334
DURBAN
4000

Fax:. 031-3085396

Dear Mr Allopi

Re: S.T.R.A.D. Conference in September 1996.

I have a pleasure in informing you that your Paper entitled: " ***Increasing the Utility of Existing Transportation Infrastructures : A Case Study*** " has been accepted for presentation in this Conference.

Presentation of Papers:

The abstract of your Paper will be incorporated in the Conference Programme Volume. Participants will base their decision to attend a particular presentation on these abstracts. If you want to revise/modify your abstract, please send the alternative version before 15 August.

Completed papers should not exceed 3000 words. Diagrams, tables and charts are not included in this word limit. Presentations will be a maximum of 20 minutes. The presenters are requested to bring 20-25 copies of their papers to the Conference. Three copies are to be given to the Conference organisers for possible publication in the Conference Volume and the remainder for distribution by the presenters themselves. Should a presenter choose to distribute only an abridged version of the paper (e.g. key points, tables, figures etc) for the presentation they may do so. In this case, three copies of the complete paper are to be given to the organisers and 20-25 copies of the abridged version retained by the presenter for distribution. (The organisers will compile a list of requests by the participants for papers and these requests will be communicated to the presenters in due course).

Equipment for Presentation:

All participants are advised that they should specify as soon as possible the equipment required for their presentation.

SOUTH AFRICAN TRANSPORT CONFERENCE

held jointly with The Chartered Institute of Transport in Southern Africa (CITSA)

16 - 19 September 1997
National Exhibition Centre, Johannesburg

Mr D E Allopi
ML Sultan Technikon
Dept of Civil Engineering
P O Box 1334
Durban
4000

13th June 1997

Dear Mr Allopi

SOUTH AFRICAN TRANSPORT CONFERENCE - SESSION ON LAND TRANSPORT

On behalf of Mr Bill Cameron, Convenor of the Sessions on Land Transport, we are pleased to advise that your paper entitled ***"Assessment of the current transport situation and its impacts on commuter perceptions: a case study"*** has been accepted for oral presentation and inclusion in the printed volume of papers for the South African Transport Conference to be held at the National Exhibition Centre in Johannesburg from 16th to 19th September this year.

We confirm that your paper will be included in the **LAND TRANSPORT II SESSION** on **Friday, 19th September**. A provisional copy of the programme for that session is enclosed for your information.

If you have already submitted your paper (either to Conference Planners or direct to Mr Cameron) it is still being reviewed. Mr Cameron has asked us to stress that if any amendments are suggested they will be of a minor nature! Hopefully we will advise you within the next week of any changes requested by the reviewer. Please could you then let us have AN ORIGINAL COPY OF THE PAPER BY NO LATER THAN 31ST JULY. Please assist us to meet this deadline - one late paper will delay the volume of papers. In case you have not already received guidelines for the preferred format, these are enclosed.

Please be kind enough to complete and return the enclosed "Author's background/Audio-visual Form". Copies of this form will be given to the chairman of your session and to the audio-visual operator.

The final announcement for the conference (which contains your name and the title of your paper) will be posted to you within the next two weeks. If you have any queries regarding your participation at the conference please feel free to contact us. With kind regards.

(Ms) Cilla Taylor and (Ms) Ammie Wissing
CONFERENCE PLANNERS

WESSEX INSTITUTE OF TECHNOLOGY

Ashurst Lodge, Ashurst, Southampton, SO40 7AA, UK.
Tel: 44 (0)1703 293223 Fax: 44 (0)1703 292853
E-Mail: wit@wessex.ac.uk

Director: Professor C.A. Brebbia

PD/UT97/20670

24 July 1997

Mr D Allopi
M L Sultan Technikon
Dept of Civil Eng.
PO Box 1334
Durban
4000
SOUTH AFRICA

Dear Mr Allopi

Re: URBAN TRANSPORT 97 - 23 - 25 September 1997 - Palazzo Cesi, Acquasparta, Italy

We are pleased to inform you that the manuscript of your paper 'Commuter Perceptions on Private and Public Transport and their Effects on Modal Choice: A Case Study' by 'D Allopi & A K Sarkar' has been accepted by the Advisory Committee for presentation at the above Conference and has now been passed for editorial review by our publishers.

Any correction to the format, layout etc will be brought to your attention by the production team who will contact you directly.

It is anticipated that you will have 20 minutes for presentation and discussion. Overhead and slide projection facilities will be available for your use (please ensure that your slides are of good quality, preferably of a plastic-framed type). Please advise if you have any other requirements which we will do our best to arrange.

Joining Instructions which include maps and accommodation details will be sent shortly. You will find enclosed a copy of our 'Notes for Presenters' which you may find useful.

We look forward to meeting you in Acquasparta in September 1997.

Yours sincerely

Paula Doughty-Young
Conference Secretariat

Enc

WESSEX INSTITUTE OF TECHNOLOGY

Ashurst Lodge, Ashurst, Southampton, SO40 7AA, UK.
Tel: 44 (0)1703 293223 Fax: 44 (0)1703 292853
E-Mail: wit@wessex.ac.uk

Director: Professor C.A. Brebbia

PD/UT97/20670

8 October 1997

Mr D Allopi
M L Sultan Technikon
Dept of Civil Eng.
PO Box 1334
Durban
4000
SOUTH AFRICA

Dear Mr Allopi

<u>Re: URBAN TRANSPORT 97 - 23 - 25 September 1997. Palazzo Cesi, Acquasparta, Italy</u>

I would like to thank you for having participated in the Third International Conference on Urban Transport and the Environment for the 21st Century (UT '97).

I was pleased at the high standard of papers and lively discussion that took place. The Proceedings are now being distributed around the world.

Although I appreciate that accessibility to the venue was not the easiest, many delegates did appreciate the historical setting of Acquasparta and the Palazzo Cesi.

I hope that you have found UT '97 of interest in your field of study and that you will be able to attend the next Conference which will be held in Lisbon, Portugal from 31 August to 2 September 1998.

Lance Sucharov
Conference Chairman

WESSEX INSTITUTE OF TECHNOLOGY

It is certified that Mr D Allopi has participated in the

Third International Conference

UT '97

Urban Transport and the Environment for the 21st Century

held fro[illegible] vith the Materials Engineering Centre, University of Perugia, Italy

Prof
Dire[illegible]
Sept[illegible]

WESSEX INSTITUTE OF TECHNOLOGY
SOUTHAMPTON · U.K

CAPE TOWN, SEPTEMBER 20-25, 1998
CODATU VIII
TRANSPORTATION AND URBAN DEVELOPMENT
SYSTEMES DE DEPLACEMENTS ET DEVELOPPEMENT URBAIN

CAPE TOWN 1998 CODATU VIII

The 28 october 1997

D. ALLOPI
Department of civil engineering
ML Sultan Technikon
PO Box 1334 Durban 4000
South Africa

Référence n° 47

Dear Sir,

Thank you very much indeed for sending me a draft paper for the CODATU VIII Conférence which will be held in September 1998 in the Cape.

The international scientific committee met a few days ago in London and selected the papers accepted for presentation.

However, the number of papers submitted was so huge that the committee had to make a very strict choice, according to the selection criterai described in the call for papers.

I am pleased to inform you that your paper entitled :

Making public transport effective :a case study

has been accepted for presentation at the Conference in the following theme : **"Transport policy"**.

I will send you the instructions for your final paper by the end of November 1997. Please note that February 15th 1998 will be the deadline for submitting your final paper.

I would be grateful if you would let me know - through a fax addressed to M. Jamet fax number (0) 147051105 - before January 15 th 1998 about your coming to the Conference to present your paper. Being in charge of the organisation of the Conference, I want to draw up the framework of the working sessions well in advance.

Should you meet any difficulties for your coming, please kindly inform me by a fax.

Thanking you for your contribution.

Yours sincerely,

Le Président du Comité Scientifique
C. JAMET