



Accommodation of BRT in the Cape Town CBD

The Study and Planning of a Bus Rapid Transit System as a
Component of Cape Town's Sustainable Transit Plan

An Interactive Qualifying Project, submitted to the faculty of
Worcester Polytechnic Institute in partial fulfillment of the requirements for the
Degree of Bachelor of Science

Submitted by:

Giselle Lewars

Omari McPherson

Nicholas Pelletier

Andrew Schwalbenberg

Submitted to:

Project Advisors:

Prof. Scott Jiusto
Prof. Stephen Weininger

Project Liaison:

Gershwin Fortune, Department of Transport, City of Cape Town

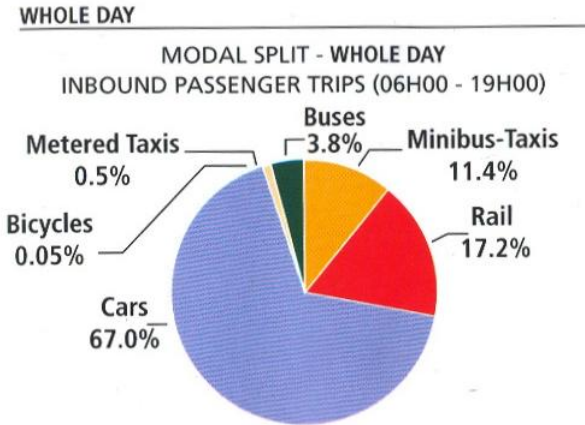
December 13th, 2007

Executive Summary

The heavy construction in Cape Town’s diverse landscape is an evident sign of the progress South Africa hopes to accomplish over the next few years. Cape Town aspires to complete a plan that anticipates millions attending the Federation International Football Association World Cup which the City is preparing to host in the year 2010. With a large sum of funds invested in the growth of this developing city, Cape Town strives to create an image that shows visitors that despite South Africa’s history, there is unity amongst the people.

Geographically, the unity South Africa attempts to portray is simply not evident. The Country’s apartheid past left the white population dwelling mainly in the City and suburbs and the majority of the poor black population remaining in settlements far away from the City centre. Despite the formal conclusion of apartheid, the informal, yet continued segregation of races has left the City’s mass transportation system insufficient in meeting the needs of all the people. Cape Town faces the challenge of bringing formerly disenfranchised individuals back into the City centre and other urban nodes for employment and services. Proper transportation is crucial in order to give those in outside settlements the opportunity to access the Central Business District’s (CBD) economic, social, and cultural opportunities as well as the ability to move easily within the City.

Although there is a functioning public transport system that consists of rail, minibus taxis, and buses, it suffers various deficiencies. The three forms of public transit are privately owned but regulated by the Government of Cape Town. There are many factors such as slow travel times, safety, image and cost that deter people from using public transport in Cape Town. Because of this, there are a significant number of privately owned vehicles creating congestion in the City’s streets. Despite the security and safety issues found with rail and minibus taxi, passengers travel on them because they are convenient and inexpensive. Our sponsor, the Department of Transport of the City of Cape Town, is attempting to develop a system that will maintain low cost and convenience while ensuring safety and security of passengers through implementing a sustainable bus rapid transit system. The vision of this plan is “to provide a world class sustainable transport system that moves all its people and goods effectively, efficiently, safely and affordably” (Integrated Transport Plan for the City of Cape Town, 2006). Bus rapid transit (BRT) integrated with other modes of mass transit can provide this access. We define bus rapid transit as bus services operating similarly to rail, mostly on separated rights-of-way with special stations and modern control systems (Vuchic, 1994).



The goal of our project was to help design a decentralised bus rapid transit route entering the Cape Town CBD from the Culemborg Corridor which has been proposed as the first phase of the City’s implementation of BRT. The success of this phase will be used to support the implementation of BRT in other areas of the City. The corridor will also serve as a symbol of

the revitalisation of Cape Town during the 2010 World Cup celebrations. Our project aimed to propose the best options for BRT design within the central business district.

The final BRT design was achieved through compiling the results from our three main objectives:

- **Identify lessons learned from the implementation of BRT systems worldwide**
- **Evaluate the needs of the Cape Town ridership**
- **Assess the feasibility of BRT along the streets and intersections within the CBD**

The methods used in the fulfillment of these objectives were interviews with BRT experts and city consultants, web and library research, the completion of an origin-destination survey, and site visits within the City including local transportation interchanges.

Identify lessons learned from the implementation of BRT systems worldwide

The need for a sustainable transport system is dire in many developing areas but most differ in their methods of implementation. There was much to be learned from the systems already in place around the world which have faced both the challenges of implementation and the difficulty of sustainability. For this reason brief case studies were used to identify best practices of BRT design. We drew on a survey conducted by Vukan Vuchic in which the transportation directors of fourteen cities reported lessons learned after upgrading their bus transit to BRT. The question was asked, “What are the most important changes that would facilitate implementation of bus service improvements and ensure their permanence?” (Vuchic, 1994). Among the changes suggested, experts emphasized the following:

- Market demand information to identify where demand could benefit from an improvement
- Improved planning policy in transit agencies
- Special bus right-of-way
- Rationalisation of route structure
- Adequate fare system
- Improved image of the bus system

From our research we were able to identify techniques used in each of the above areas to ensure a sustainable system. For example, decentralisation is a technique used in route structuring. This practice is a means of dispersing passengers throughout the CBD rather than at one central terminus. Due to its benefits, decentralisation was found in most case studies. The TransMilenio system in Bogotá, Columbia is considered a prime example of how BRT and decentralisation can remove congestion (Cain et al., 2006). Along with decentralisation, another constant found in most of the case studies was dedicated lanes. In most cases, these lanes are the two centermost and are set aside for use by the rapid transit buses. This feature helps to achieve the goal of true “rapid” transport. These dedicated lanes help to entice passengers to use the system and were one of the factors that led to success in many case studies.

Evaluate the needs of the ridership

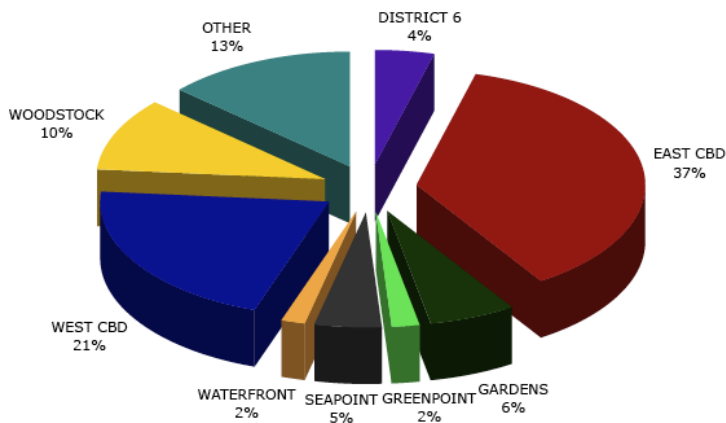
We developed an origin-destination survey (ODS) as a way to assess the needs of passengers currently using public transportation along the Culemborg Corridor. The ODS concentrated on recording the starting point of a passenger's trip using the existing mass transit modes as well as his/her final destination. In addition, the survey collected information on the main complaints of the ridership along the corridor.

While surveying, we observed that there are a large number of empty buses entering the CBD daily, meaning infrastructure is currently being used inefficiently and ineffectively.

Furthermore, a majority of the passengers who do get off in the City do not depart at the Bus

Terminal. Instead, these passengers disembark from the bus in a decentralised fashion as the buses approach the terminal, in order to get to their desired destination. This observation supported the idea of creating decentralised routing within the CBD, eliminating the need for a central terminal. These two observations, along with the major passenger complaints, were also considered during the final routing design.

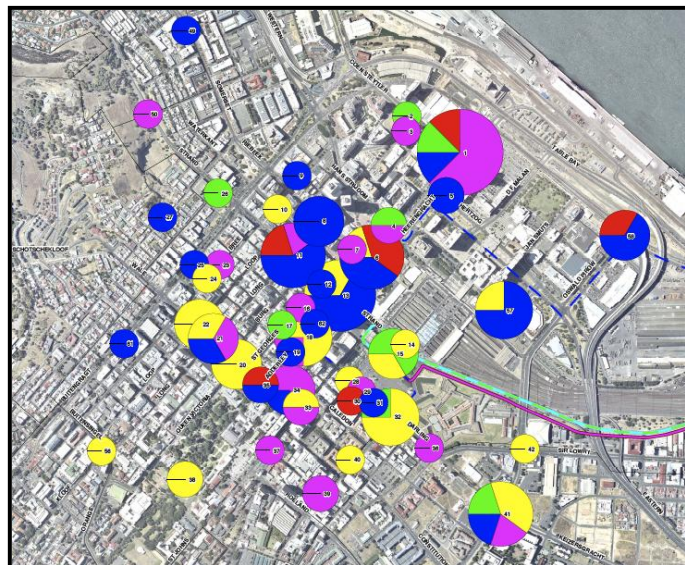
PASSENGER DESTINATION BY AREA



The surveying found over fifty percent of the ridership was heading directly into the central

business district (East CBD and West CBD) while just under ten percent of passengers were heading in the direction of Sea Point. We used GIS mapping to compile the final destinations of

all the passengers surveyed. From these maps, the areas with the highest need could be identified. The circles in the mapping refer to the varied destinations, while the colors correspond to the origin of each passenger. This mapping was necessary in order to develop routing that adequately met the needs of the passengers entering the CBD. The goal was to bring routing within 500 metres of ninety percent of the passengers, minimising the need for transfers within the system.

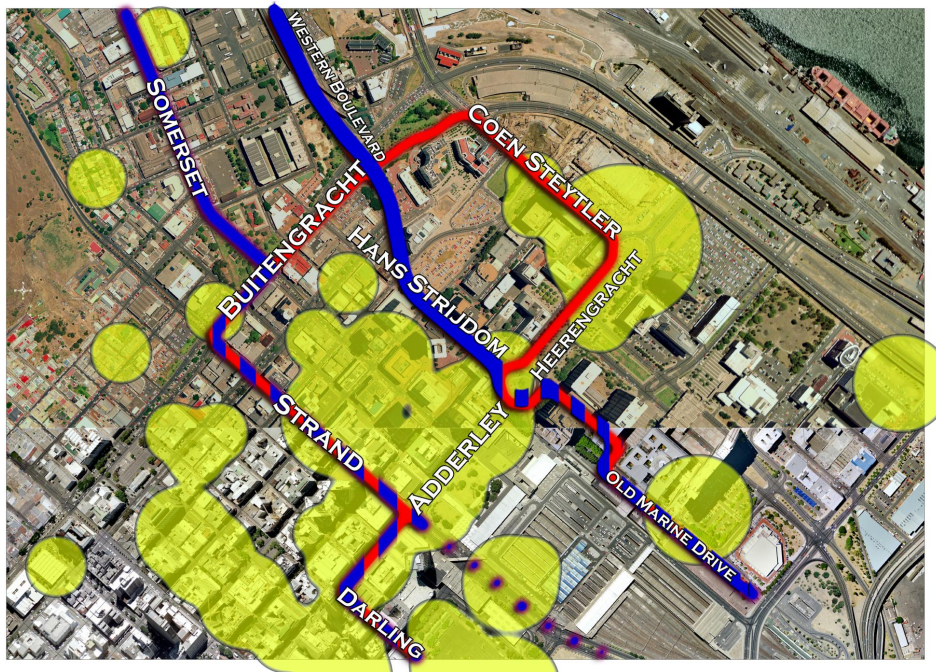


Mapping of passenger destinations

Using this information, we evaluated the potential routes for BRT in the CBD. The routing aimed to:

- Meet passenger demands
- Follow a decentralised loop incorporating the “SuperBlock”
- Address the need for routes that continue on to Sea Point (a major destination)
- Utilise streets capable of having a dedicated lane
- Meet 2010 World Cup needs

The final routing we designed would meet the needs of eighty percent of the passengers by bringing them within 500 metres of their final destination. While creating these routes, we recognised that additional routing will be necessary in a second phase to meet the needs of every passenger. With this in mind, our proposal was designed with the goal of making additional phases easy and seamless. It also addressed the need for continued service to Green Point and Sea Point, which will be important during the 2010 World Cup.



Assess the feasibility of BRT along the streets and intersections within the CBD

In assessing the feasibility for BRT along the streets and intersections, it was necessary to create a station design that would be implemented along the route. We had found that there are three major decisions that needed to be made in order to properly begin planning the BRT stops within the CBD. One was fare collection, as facilities necessary at a given stop are defined by the way fares are collected. We were instructed by our liaison to assume that Cape Town will be

using a flat fare system. The primary reason for this assumption is both social and economic. A zonal fare system would mean that poor people on the outskirts of the City would be forced to pay more than wealthier citizens closer to the CBD.

The other two decisions that had to be made were whether the stations would be kerbside or median, and closed or open. We were hesitant to say that a median arrangement would fit within the already congested and sometimes quite narrow streets. The decision was that open kerbside stations were the best proposition for Cape Town. We developed a design for a kerbside stop that projects the modern image of the system while allowing each stop to be unique and representative of the diverse culture of the City through contributions by local artisans.

Our work concluded with on-site feasibility analysis that assessed the impact on the streets and intersections along our proposed route. It includes pictures of various locations along the route with comments that identify potential



station locations, urban design concerns, and planning issues. The purpose of this model is to give a visual representation of the route along with its perceived challenges, with the intention of generating feedback and discussions with stakeholders of this Inner City BRT Project.

This on-site feasibility, in addition with the routing and station design, fulfills the objective of responding to the needs of the ridership as well as the objective of evaluating the potential for BRT within the City. Our proposal for BRT implementation contributes to the overall plan to revitalise public transportation in the City of Cape Town

Table of Contents

Table of Figures	vii
Table of Tables	vii
Glossary	x
1 Introduction	1
2 Background	2
2.1 <i>Cape Town's Current Transportation Challenges</i>	2
2.1.1 Overview of the Current Public Transport Record	3
2.1.2 Rail	4
2.1.3 Bus	4
2.1.4 Minibus	4
2.1.5 Summary	5
2.2 <i>Bus Rapid Transit</i>	5
2.2.1 History of BRT	5
2.2.2 Motivation to Implement a BRT System	5
2.2.3 Benefits of the BRT System	6
2.2.4 Problems with Implementing a BRT System	6
2.3 <i>Examples of BRT Systems Worldwide</i>	7
2.3.1 Bogotá, Columbia	7
2.3.2 Brisbane, Australia	7
2.3.3 Curitiba, Brazil	8
2.3.4 Guayaquil, Ecuador	8
2.3.5 Honolulu, Hawaii, USA	9
2.3.6 São Paulo, Brazil	9
2.4 <i>Lessons Learned</i>	10
2.4.1 Decentralisation	10
2.4.2 Ridership	12
2.4.3 Public Participation	13
2.4.4 Dedicated Lanes	14
2.4.5 Stations	15
2.4.6 Fare Collection	17
2.4.7 Route Planning	19
2.4.8 Privatisation	19
2.5 <i>Summary</i>	20
3 Methodology	21
3.1 <i>Collection and Comparison of BRT Station Designs</i>	23
3.2 <i>Origin-Destination Survey</i>	23
3.3 <i>Organisation and Mapping of Survey Data</i>	24
3.4 <i>Routing and Station Design</i>	26
4 Results and Analysis	28
4.1 <i>Origin-Destination Survey</i>	28
4.2 <i>Route Planning</i>	34
4.3 <i>Station Design</i>	36
4.4 <i>On-site Feasibility Analysis</i>	41
5 Conclusion	60

6	Works Cited	61
7	Appendix A: Supplementary Figures and Tables	63
8	Appendix B: Interviews	67
	8.1 Interview with Lloyd Wright	67
	8.2 Interview with Frederick De Villers	68
9	Appendix C: Station Design Manual	69
10	Appendix D: ODS Survey	85
11	Appendix E: Annotated Bibliography	86

Table of Figures

Figure 2.1	Percent Employment Using Car	2
Figure 2.2:	Cape Town Transportation Statistics	3
Figure 2.3:	Colectivos of Guayaquil	8
Figure 2.4:	Curitiba's System of Bus Services	11
Figure 2.5:	Bogotá Before and After the TransMilenio	12
Figure 2.6:	Example of Removable Dedicated Lane System	14
Figure 2.7:	Dedicated Lanes	14
Figure 2.8:	BRT Station in Brisbane, Australia	16
Figure 2.9:	Median BRT Station Layout	17
Figure 2.10:	Electronic Fare Box	18
Figure 2.11:	Smart Card Technology	18
Figure 3.1	Methodology Flow Chart	21
Figure 3.2	Aerial View of the Proposed Culemborg Corridor	22
Figure 3.3	Gantt Chart of Project Tasks	23
Figure 3.4:	Zoning of the CBD used for ODS Analysis	25
Figure 3.5:	Components of the Final Project	26
Figure 4.1:	Major Complaints about Public Transportation	28
Figure 4.2:	Passenger Final Destination by Area	29
Figure 4.3:	Legend of routes, origins, and passenger quantities	30
Figure 4.4	Surveyed Routes in the Culemborg Corridor	31
Figure 4.5:	GIS Mapping of Passenger Destinations	32
Figure 4.6:	Zoom in on the CBD	33
Figure 4.7:	Routing Design	35
Figure 4.8:	Adderley St	37
Figure 4.9:	York, Ontario, Canada Kerbside Station	38
Figure 4.10:	Front view of Station Design	39
Figure 4.11:	Aerial Station View	39
Figure 4.12:	Locations included within the On-site Feasibility Analysis	41

Table of Tables

Table 2.1:	Number of Passengers Transported during the First Three Months of 2007	9
Table 2.2:	Typical BRT Station Spacing	16
Table 4.1	Benchmark Comparison Chart of Station Designs	36

Abstract

Our goal was to develop a routing design and on-site feasibility analysis for the proposed bus rapid transit system within Cape Town's central business district, utilising the concept of decentralised boarding and disembarking. This project was initiated due to deficiencies in the current public transport system with regard to security, speed, and comfort. With our research into these systems, in addition to assessing the needs of current passengers through surveying, we developed a routing plan for the central business district, designed and proposed station concepts, and conducted an on-site feasibility analysis. These results contribute to the overall remodel of Cape Town's public transportation in an attempt to move past the lingering effects of apartheid as well as prepare for the City's hosting of the 2010 FIFA World Cup.

Acknowledgements

This project would not be possible without the help and guidance from various individuals and organisations. We would first like to thank Mr. Basil Tommy for his hard work in organising our project and establishing contacts. In addition we would like to recognise our liaisons from the City of Cape Town, Mr. Gershwin Fortune and Mr. Abdul Bassier, for their guidance and help with our project, it is very appreciated and was crucial for the success of our project.

We greatly appreciate the help and direction from Mr. Malvyn Carlese. Without his help, our project would be incomplete. We would also like to recognise Ms. Niki Covary with her assistance in surveying and project input. In addition, the help from Mr. John Spotten with data analysis and mapping was key for our project and most valued. The assistance of Ms. Nolubabalo “Nototo” Mgudlwa (Civil Engineer), Mr. Greg Hendricks, Moegamad Fortune, and the help of the City of Cape Town’s data collection team was very valuable, and we greatly appreciate their support. In addition, Mr. Neil Jacobs’ assistance with the City’s GIS and mapping was extremely helpful.

Our thanks are also extended to Mr. Fredrick de Villiers of HHO Africa Infrastructure Consultants and Arcus Gibb Consulting Firm. Also Dr. Lloyd Wright from *Viva Cites* was a great help to our project and more than willing to help at any hour. All of their help in route planning and current system analysis was very beneficial and much appreciated.

Last but not least, we would like to thank our project advisors, Professors J. Scott Jiusto and Stephen Weininger. Without their help, guidance and direction our project would have suffered. We greatly appreciate their assistance.

Glossary

BRT	Bus Rapid Transit
BINB	Brisbane Inner Northern Busway
BSEB	Brisbane South East Busway
CBD	Central Business District
GABS	Golden Arrow Bus Services
GIS	Graphic Information Systems
HOV	High Occupancy Vehicle
IDP	Integrated Development Plan
ITN	Integrated Transport Network
ITP	Integrated Transport Plan
ITS	Intelligent Transport Systems
LRT	Light Rail Transit
NMT	Non-Motorised Transport
SABOA	South African Bus Operators Association
SOV	Single Occupancy Vehicle

1 Introduction

In developing areas, such as South Africa, degradation of public transport due to over population and lack of investment has been a re-occurring issue. The country of South Africa, in particular, has a unique past involving apartheid which forced citizens into separate race communities. In the City of Cape Town, this left the white population dwelling mainly in the City and suburbs and the majority of the poor black population remaining in settlements far away from the City centre. Despite the formal conclusion of apartheid, the informal, yet continued, segregation of races has Cape Town's mass transportation system insufficient in meeting the needs of the people. In Cape Town, proper transportation is crucial in order to give those in outside settlements the opportunity to access the Central Business District's (CBD) economic, social, and cultural opportunities as well as the ability to move easily within the City. These needs have led the City of Cape Town to pursue the implementation of a large-scale sustainable public transportation system.

When creating a sustainable transit system it is important to consider the integration of multiple forms of transportation. One of the methods of transportation commonly found in newer systems around the world is bus rapid transit (BRT). We define bus rapid transit as bus services operating similarly to rail, mostly on separated rights-of-way with special stations and modern control systems (Vuchic, 1994). In many cases, BRT passengers have experienced significant decreases in travel times and less congestion on the streets. However, there are many challenges in upgrading bus systems and developing an effective strategy for implementation. Therefore, establishment of a sustainable transit system including BRT is not a simple task.

There is much to be learned from cities such as Brisbane, Bogotá, Curitiba, Honolulu, and Guayaquil that have successfully instituted bus rapid transit. In most cases, travel times decreased greatly with the new systems and overall passenger approval increased. Though BRT has proven to be effective, it is not perfect. For example, the BRT in the city of São Paulo is considered mediocre at best. The ridership of this system is very low and citizens are choosing other forms of transportation, adding to the congestion and pollution in the city. In transit planning, it is important to take into consideration both the successes and failures of other cities as they contain important lessons to be learned.

Cape Town has not implemented a BRT system, but is committed to the completion of the first phase by commencement of the 2010 Federation International Football Association World Cup which the City is hosting. To create a successful system, it is crucial to develop a plan for transport in the CBD that falls within the constraints and user requirements of the region. It is impossible to find one system that will work effectively in every city across the world. Therefore, in our research, it was important to identify cities with elements that parallel the unique aspects of Cape Town. With these cities identified, we looked at routing methods that are applicable to the design of a BRT system in the City, both conceptually and directly.

The goal of this project was two-fold. The first part was to research various related bus rapid transits in other cities and apply features to a decentralised BRT system in the Cape Town central business district. The data collected were used to create a system that will serve as many people as possible. Second, we developed a strategic on-site feasibility analysis of how the application of a bus rapid transit system would work in the Cape Town CBD originating from the high volume Culemborg/Atlantis Corridor. Through our research, data collection and route planning we strove to effectively meet these goals, thus submitting this final report for our Interactive Qualifying Project.

2 Background

Cape Town, South Africa, is starting to implement an integrated mass transit system. A part of the master plan includes bus rapid transit as a way to encourage the use of public transport within the City. In this chapter, we explain our research on Cape Town’s current system. We will also focus on bus rapid transit, including case studies from which many lessons can be learned. Through this research, we have gained a better understanding of BRT as a whole as well as the unique components which lead to its successes or failures.

2.1 Cape Town’s Current Transportation Challenges

In Cape Town, the legacy of apartheid is reflected in the population distribution. During the apartheid era, blacks were evicted from city centres and forced into townships outside the City. These townships were often built on impoverished land and standards of living were significantly lower than those experienced by whites in other areas. At the same time, people from rural villages in search of a better life left their homes and settled in and around these townships, creating “informal settlements.” The Cape Flats, located south east of the CBD, are where many of these townships can be found. Today, Cape Town faces the challenge of bringing formerly disenfranchised individuals back into the City centre and other urban nodes for employment and services.

Cape Town “provides services to approximately 800,000 households and jobs to 1.1 million people” (Integrated Transit Plan, 2006). In Figure 2.1, the yellow and light blue areas represent where the use of public transport is very high. Currently, in areas such as Khayletisha and Mitchells Plain the demand is being met mostly by rail and mini-bus taxi. By contrast, the dark blue areas such as the northern and western suburbs have large percentages of private cars

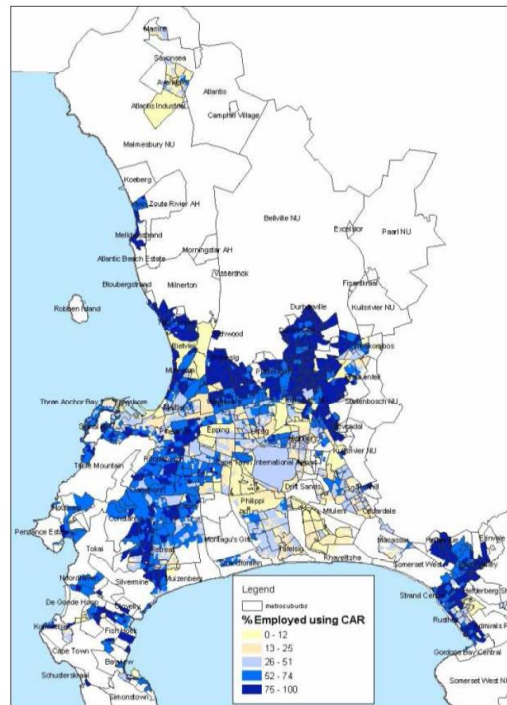


Figure 2.1 Percent Employment Using Car

Source: IDTP, 2006

commuting into the CBD, contributing to much of the congestion and pollution. The City’s 2003 Mobility Strategy seeks “to ensure that access and mobility needs of all citizens, visitors, goods and services are well managed, delivered and met in a socially just, equitable and sustainable manner” (Mobility Strategy, 2003). Bus rapid Transit integrated with other modes of mass transit can provide this access.

2.1.1 Overview of the Current Public Transport Record

Cape Town’s Current Public Transport Record (CPTTR) contains key statistics regarding the City’s mass transit usage. These statistics include, services offered, passenger numbers, and frequency of services, in addition to routes and fare structures. It is important to evaluate the CPTTR as it helps to identify specific areas where public transport is deficient, thus providing a foundation on which major planning decisions can be made.

As seen in Figure 2.2, of the approximate one million passenger trips made a day, fifty-four percent are made by train, twenty-nine percent are by minibus taxi, and seventeen percent are by

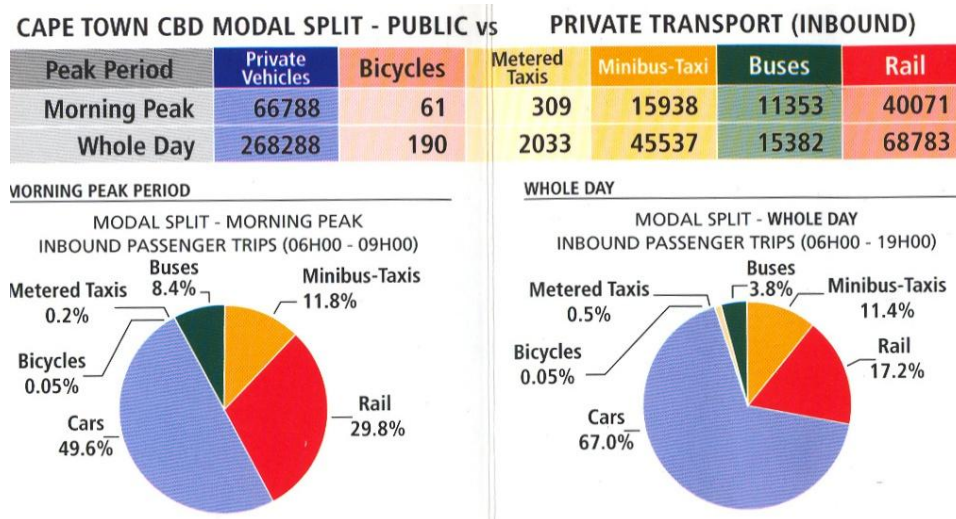


Figure 2.2: Cape Town Transportation Statistics

Source: CPTTR

bus. This public transportation accounts for thirty-three percent of people traveling into the central business district (CBD) daily, while the other sixty-seven percent travel in private cars. These are generally single occupancy vehicles that contribute to the congestion in Cape Town. The first pie chart of Figure 2.2 shows in blue that during the morning peak hour (0600 to 0900), about fifty percent of passengers travel into the CBD using private car. In contrast, the left pie chart shows that in total throughout the day about seventy percent of travel is done by private car. This is due to the fact that during off peak hours (0900 to 1600), with fewer people using the system, it is considered less safe to travel on public transport. This shows that safety and security is a major concern in Cape Town’s current transportation system.

Over the past ten years, the number of bus passengers during peak hours has declined while the ridership of mini-bus taxis has increased. The number of rail trips made during peak

hours has stayed just about the same. The reasons for these increases and decreases are important in that they show the wants and needs of the ridership. These reasons can be found through analysis of each separate service.

2.1.2 Rail

Cape Town's rail system brings around 308,000 passengers into the city daily. There are eight main train lines that serve the City: Cape Flats, Khayelitsha, Kraaifontein, Lavistown, Mitchells Plain, Monte Vista, Simon's Town and Strand. Of these, Khayelitsha, Mitchells Plain and Strand carry fifty-one percent of all boarding passengers.

The train fares are the most competitive for traveling long distances. There are four different distance category zones of which the first consists of one to twenty kilometres and the following zones increase at fifteen kilometre intervals with the last zone including fifty-one kilometres and more.

Train service has remained constant in ridership despite the lack of security being an issue. This is due to the low price and rapid speed which make it a practical choice for many passengers.

2.1.3 Bus

Bus services throughout the City of Cape Town are operated by Golden Arrow Bus Services (GABS) and Sibenye, both privately owned and managed entities; however station logistics and licensing is regulated by the City of Cape Town. Both operators are members of South African Bus Operators Association (SABOA). Collectively the system carries 197,000 passengers daily on 852 separate buses. Out of the 132 bus facilities, Golden Acre, located in the CBD, is the busiest throughout the day with a total of 38,000 passengers. Departures and arrivals are typically scheduled between zero and thirty minutes apart depending on location and route. A minimum cash fare of R 2,30 is charged increasing with distance traveled up to R 14,10 for a fifty kilometre trip.

Bus travel is considered by most to be the safest mode of public transport. Despite its safety, there has been a decline in ridership due to the longer travel times and higher cost.

2.1.4 Minibus

Minibus taxi's are privately owned single vehicles or privately owned small fleets, with many owners belonging to taxi associations. Similar to buses, taxi operators acquire operator licenses or permits for a specific route to operate in the system. The central terminal in the CBD is the hub for minibus loading and unloading; however, the flexible system allows for intermediate alighting and loading at passenger specified locations. With this current system a passenger waits between ten and forty-five minutes off peak to leave the CBD as operators wait for the minibus to be full before departure. During peak hours, minibuses are cycled through the station constantly with little wait time between. Fares are typically R 4,50 and are collected by the driver or an onboard conductor. The fares may increase depending on the distance traveled and these increases are determined by the operator, usually not exceeding a maximum fare of R 7,00. While the waiting times at interchanges can be inconvenient and many operators drive recklessly, ridership has increased. This is due to the low cost, flexibility, and speed of the system which is attractive to many passengers.

2.1.5 Summary

The options for public transportation in the City of Cape Town are numerous and diverse. The overview of each mode of transport highlights aspects of the system that both attracts and deters ridership. We are able to see the advantages and disadvantages of the each system and compare them with the ridership patterns from each mode. The bus overview shows a decrease in the ridership despite the security and safety. This decrease shows that even though passengers are safe on the bus, there is a preference to take another mean of transport because of either the price or the time of the trip. The train overview shows an increase in ridership despite the low safety factor. This increase shows that even though passengers are not safe on the train, there is a preference to take it despite its disadvantages. The passengers of train remain because it is fast and less expensive. The overview of the minibus taxi shows an increase in ridership despite the low safety factor. This increase shows that even though minibuses drive erratically, it is preferred because it is fast, convenient and the least expensive.

In many cases, it is these disadvantages that have caused patronage in some modes to decrease. It is important to address these disadvantages to create an overall better public transit system. The data contained in the CPTR are crucial in order to identify where improvements can be made in the overall system and to identify sections of the overall system that are truly excelling. Bus Rapid Transit is a system that aims to fulfill the obvious need for speed, reliability, and low cost while maintaining safety and security of the passengers.

2.2 *Bus Rapid Transit*

Bus rapid transit (BRT) is a broad term that encompasses a variety of systems that use innovative infrastructure and scheduling to provide a service that is faster than the local bus operations. Each BRT uses its own unique features but there are many features which are shared by a majority of systems. To provide a reliable means of commuting, BRT uses high capacity buses and dedicated lanes to lessen traffic congestion. As a whole, BRT attempts to achieve the efficiency of rail transit while maintaining the flexibility and lower cost of bus transit.

2.2.1 History of BRT

The first prototype of a BRT system was in Chicago, IL, USA in 1937. In order to travel into the central commercial district, local officials planned to convert three west side rail lines to a bus system with dedicated highways. The current systems of the world have the same premise, but a different approach. The first modern day system can be seen in Curitiba, Brazil, where buses travel on dedicated lanes making several stops on designed routes. These buses keep millions of commuters moving rapidly around the city every year. This system is the first modern day BRT.

2.2.2 Motivation to Implement a BRT System

For many cities worldwide, the main reason for implementing the BRT system has been the need for a cost effective way to reverse the deterioration of mass transit lines and ridership. Since the vast majority of mass transit systems were constructed many years ago, the infrastructure of that initial development is slowly deteriorating, and as a result is becoming more expensive to build and maintain. Underground metro systems in particular can cost millions of dollars to maintain due to their complexity. A city must either continue maintaining their existing infrastructure or create a new model that better meets their needs. As a result, city planners are turning to bus rapid transit to achieve the regularity and reliability of a rail system

with the flexibility and accessibility of an on ground bus system. This motivation creates the driving force for the continued implementation of bus rapid transit worldwide.

2.2.3 Benefits of the BRT System

The bus rapid transit system was initially implemented as a cost effective measure to enable mass transit in cities. By correctly implementing BRT, a city creates a useful and economical alternative to a subway or elevated rail system which both cost more than BRT. Many cities profit from the system while maintaining reasonable fares for passengers. In addition, BRT is easy to maintain, quicker to implement, environmentally friendly, and reliable.

Bus rapid transit is easy to maintain in that compared to metro systems, where the trains are confined to a track, the buses are able to adapt to shifting conditions more readily. For example, if a bus station was under construction and a detour was required, a bus could easily take a different route for a certain period of time. A rail system, on the other hand, would not be able to do so and the entire rail line could be shutdown.

Bus rapid transit systems, in general, are also quicker to implement than traditional light rail or metro systems. Typically, dedicated lanes can be laid on top of existing roads. Conversely, rail systems require the laying of tracks for many miles which can involve clearing of land, relocation of residents and the complexity of maneuvering around existing roads, bridges and other obstacles. A metro system requires miles of tunnels below a city which leads to a long implementation time period. A BRT is able to extend onto existing highways and roads creating a very seamless integration. If dedicated lanes are needed, additional lanes may have to be constructed or BRT can also travel with normal traffic when necessary.

Pollution is also a growing social concern that has been addressed by the BRT system. Bus rapid transit in general lowers emissions. Due to the unique operation of the BRT, buses can travel faster to their destination, lowering idling times as well as decreasing fuel consumption. The placement of the stops and the implementation of the dedicated bus lanes are responsible for this added benefit and are seen as the unique part of the BRT system.

There is also the psychological aspect of bus rapid transit. A BRT system is constantly moving with little time spent at stations creating the effect of constant motion. A metro or a traditional bus system does not have the same effect. Traditional buses are seen frequently on the side of the road waiting to re-enter already congested traffic. The metro is underground and does not stretch as far as a BRT system in cities (Levinson *et al.*, 2003). This psychological effect influences the passengers on the BRT. Being taken from ones origin to destination on a fast moving vehicle with little or no hassle encourages the use of mass transit. The passengers can relax in the increasingly rider-friendly and technologically advanced buses. This mode of transport is far less stressful than sitting in traffic for long periods of time.

2.2.4 Problems with Implementing a BRT System

There are many factors that need to be taken into consideration when implementing a BRT. These issues include public interest, funding, road management, downtown route planning and effect on privately owned vehicles. Some concerns can be addressed with strategic planning and implementation. One of the problems to work around is public interest. In some cases, citizens oppose the construction of a new BRT system. Dedicated lanes can create more congestion for private operators and can create hostility towards BRT. One way to avoid opposition is to involve the public in the planning of the BRT and keep them actively involved in the progress and future developments. People respond better to change if they have a part in it.

By allowing the input of the citizens, people take ownership of the project and contribute to its success. So while there may be some strong opposition at first, if the BRT is properly implemented and if the public is involved in its planning and implementation there is a strong chance for success and an increase in ridership.

Although the BRT system is one of the less expensive systems, its initial investments can be expensive. To deal with the cost, many cities use strategically planned phases for the implementation of the system. This is beneficial in two ways. First, it spreads the total investment out over an extended period. Second it allows for experimental routes. By placing a route and receiving feedback about its operations, a more comprehensive plan for the next phase can be produced.

One of the major components of the BRT is the fast moving, unimpeded flow of buses between stations. Due to the inability to control traffic flow and the narrowness of downtown streets, the dedicated lanes found in BRT are sometimes unable to be utilised. In these cases, lanes are used to designate bus placement in the road way or the buses can be mixed with general traffic. Both of these methods are less than ideal but are necessary in certain areas in order to continue service through the central business district. Congestion in the CBD has led many cities to use decentralised routes around the city in order to disperse occupants around the area instead bringing them to a central location. Through properly dealing with these problems, a reliable, successful form of mass transit can be achieved.

2.3 Examples of BRT Systems Worldwide

Bus rapid transit has become a more prevalent form of mass transit in recent times. There is much to be learned from these systems as they have faced both the challenges of implementation and the difficulty of sustainability. The following section will discuss several examples of BRT systems through brief case studies.

2.3.1 Bogotá, Columbia

Bogotá, the capital of Columbia, has an estimated population of eight million people (Cain, A., *et al.*, 2006). Prior to 2000, Bogotá's public transportation was not a widely used service. Many individuals used private vehicles causing excessive congestion. For this reason, Bogotá embarked on the creation of what is now one of the world renown BRT systems, the TransMilenio.

The TransMilenio is the centerpiece of a long-term urban renewal and mobility strategy that prioritises walking and cycling and discourages private vehicle use. The system now carries over one million passengers a day (Cain, A., *et al.*, 2006). These high volumes are made possible by a wide variety of system design features, including high capacity buses, exclusive runningways, level boarding, off-board fare payment, and high service frequencies that permit loading times as low as thirteen seconds on busy sections of the system. The system is also completely decentralised. There are multiple high capacity trunk corridors from which runs a separate feeder route system. These system design features have greatly reduced congestion and significantly increased ridership of the system.

2.3.2 Brisbane, Australia

Brisbane, the capital of Australia, is regarded as having the country's most effective bus transit system. The greater Brisbane area has an estimated population of 1.7 million and is home to two major bus rapid transit systems (Brisbane, 2006). Up until the 1960s, the primary forms of

public transport in Brisbane were tramways and bus trolleys. By 1969, the last of the tramways had been demolished and replaced with an extensive fleet of buses. Over the next two decades, however, the bus system suffered from a continued decline in ridership. Buses grew old, fuel costs increased and funds intended for replacement buses were misallocated by the state government. In addition, stringent budget cuts to the Transport Department led Brisbane's bus system into a state of emergency.

In the 1990s Brisbane corporatised its transit services and formed Brisbane Transport, a council-owned company. Brisbane Transport has implemented two easily accessible busways with high-frequency express routes: the Brisbane South East Busway (BSEB), and the Brisbane Inner Northern Busway (BINB). Three additional busways have been proposed and are under development with expected completion by the year 2012. Riders now also have a single integrated ticketing system called the TransLink which makes paying the fare much easier. Brisbane no longer worries about lack of ridership; today they are concerned with solutions to overcrowding on the highly popular busways (Brisbane, 2006).

2.3.3 Curitiba, Brazil

Servicing the 2.7 million people (Britannica, 2007) of Curitiba, Brazil, is the Integrated Transport Network (ITN). In the 1960s, the city recognised that one of the keys to sustainability is a fast, efficient, and affordable public transit system. Under the leadership of former mayor Jaime Lerner, the ITN was developed and became fully operational in 1982. It is important to note that the early implementation of Curitiba's bus system, along with land and zoning policies, has helped direct the growth of the city in a decentralised fashion (Levinson *et al.*, 2003).

The ITN consists of five major busways that radiate from the city centre. Stations are elevated and fares are collected at the station to allow for quick boarding times. Private bus companies provide the service and are paid by the city according to bus distance traveled. The system is patronised by seventy-five percent of weekday commuters because of its efficiency, reliability, and well integrated express and feeder routes (Freiburg, 2001). Today, Curitiba is viewed as the cornerstone of BRT systems.

2.3.4 Guayaquil, Ecuador

Guayaquil, Ecuador's largest city, is home to three million people, of whom, eighty-three percent use public transportation. The city was recently noted for winning the 2007 Sustainable Transit Award after successfully implementing a bus rapid transit called the Metrovía (Buchwald, 2007). Originally, private buses known as colectivos, shown in Figure 2.3, would



Figure 2.3: Colectivos of Guayaquil

Source: Bus, 2007

run their own routes, competing for passengers. This system was “characterised by an oversupply of buses...a duplication of routes that added to traffic congestion, obsolete or non-existent infrastructures, fierce competition between bus owners, and a guerra del centavo (a battle for passengers)” (Buchwald, 2007).

In August 2006, under the direction of Mayor Federico Von Buchwald, Guayaquil introduced the first phase of the Metrovía. This initial phase included new high-capacity articulated buses, new train-like stations and the first of seven trunk routes. According to a survey conducted by Guayaquil City Council in August 2006, seventy percent of the people rate the service as “good to excellent” (Buchwald, 2007). This service has resulted in a substantial increase in ridership as shown in Table 2.1. Once two additional routes have been added, the first phase of the Metrovía is expected to serve over 600,000 people per day.

Month	Passengers transported
January	1,598,823
February	2,278,269
March	2,727,572

Table 2.1: Number of Passengers Transported during the First Three Months of 2007

Source: Buchwald, 2007

2.3.5 Honolulu, Hawaii, USA

The city of Honolulu is a very popular tourist destination on the islands of Hawaii. The core population is just around 900,000 people (Cham *et al.*, 2006). Prior to 1995, Hawaii’s main transportation was isolated local bus routes. These routes were very limited and were not properly serving the residents and tourists of Honolulu.

In hopes to improve the mass transportation system, in 1992 Honolulu contracted Oahu Transit Services, Inc. for operations of “The Bus”. This corporation is a non-profit organisation that was established as an entity of the city. The city also began discussing an overhaul to its mass transportation. It was decided that the island of Honolulu would benefit significantly from bus rapid transit. Originally, there was much resistance from the citizens in the city who did not want such an implementation on their island. Since the official opening of the last of the four routes in 2004, it has become evident that the bus rapid transit system has been very beneficial to the city of Honolulu. Overall, it has decreased travel times for its passengers by as much as thirty-three percent (Cham *et al.*, 2006) making passengers very satisfied with the new structure as rated in recent surveys. This positive rating is attributed in part to the extensive public participation that was conducted during the systems introduction. This outreach ensured the system would fit the needs of the ridership in the city.

2.3.6 São Paulo, Brazil

São Paulo, in Brazil, contains one of the country’s main transportation centres and has the largest transit system in Latin America. The city’s population consists of about eleven million

people of whom eight million are daily bus passengers (Golub, Hook, 2003). São Paulo's bus system, once the focus of modern transportation planning because of its outstanding accumulation of capital, great development, and attractive investments is now perceived as a deteriorating organisation.

The city had many incentives for introducing a bus rapid transit and commenced the BRT project in 1979. It wasn't until the mid 1990s that it became problematic. Bus operations in São Paulo are privately owned and until recently were not under any concession contracts. Privatisation acted extremely negatively and is hurting not only the passengers of the bus routes who lose their jobs, but the economy as well (Golub, Hook, 2003). A recent attempt to modify the system by the Government led to a multitude of violent strikes. The failures of the system have created an intolerable congestion and a chaotic environment in which the ownership of cars is increasing and informal mini vans are becoming more popular because of their affordability and convenience.

2.4 Lessons Learned

In each of the case studies cited, strategic decisions have been made throughout the planning of each system. In some cases, these decisions have proved to be extremely beneficial while in the case of São Paulo, other decisions have led to less successful results. In a survey conducted by Vukan Vuchic, the transportation directors of fourteen cities reported lessons learned after upgrading their bus transit to a BRT. The question was asked, "What are the most important changes that would facilitate implementation of bus service improvements and ensure their permanence?" (Vuchic, 1994). Among the changes suggested, experts emphasized the following:

- Market demand information to identify where demand could benefit from an improvement (Decentralisation and Ridership)
- Improved planning policy in transit agencies (Privatisation and Public participation)
- Special bus right-of-way (Dedicated Lanes)
- Rationalisation of route structure (Route Planning)
- Adequate fare system (Fare Collection)
- Improved image of the bus system (Station Design)

The following sections address these issues in more detail. In each of these areas, there are lessons to be learned regarding the strategy behind a successful bus rapid transit system. With the compilation of these lessons, we can both avoid the mistakes made by others while capitalising on the successful practices they have already discovered.

2.4.1 Decentralisation

Decentralisation is the method of dispersing passengers throughout the CBD rather than at one central terminus. Due to its benefits, decentralisation is a constant goal in the planning of a BRT. Two of the celebrated aspects of a BRT system are the decreases in passenger transfers and number of terminals. These aspects allow for fast travel times increasing the effectiveness of the system. Decentralisation works well for the vast majority of BRT systems around the world. In certain circumstances, however, a central terminal is necessary. Several cities in the United States have large central area bus terminals, specialising in commuter or express bus services. The Port Authority terminal in New York and the South Station Bus terminal in Boston are two examples of such terminals. These terminals are successful because they are located on the edge of the CBD and provide access to the city centre, close to major employment areas.

The disadvantage of these terminals is that they are not suited for high frequency BRT operations. Their size and complexity creates large overhead and operating costs. Also, these terminals do not allow for through service, forcing passengers to transfer. Transfers, in turn, increase travel times and diminish customer satisfaction. One of the main goals of the more recent BRT designs is to minimize the need for transfers. Given these factors, central terminals are typically counterproductive and should be carefully considered in a well integrated BRT. The most efficient system is one in which buses remain in CBD streets or busways, as this allows for quick loading and alighting of passengers. Curitiba's system of bus services, shown in Figure 2.4 is one example of a decentralised system.

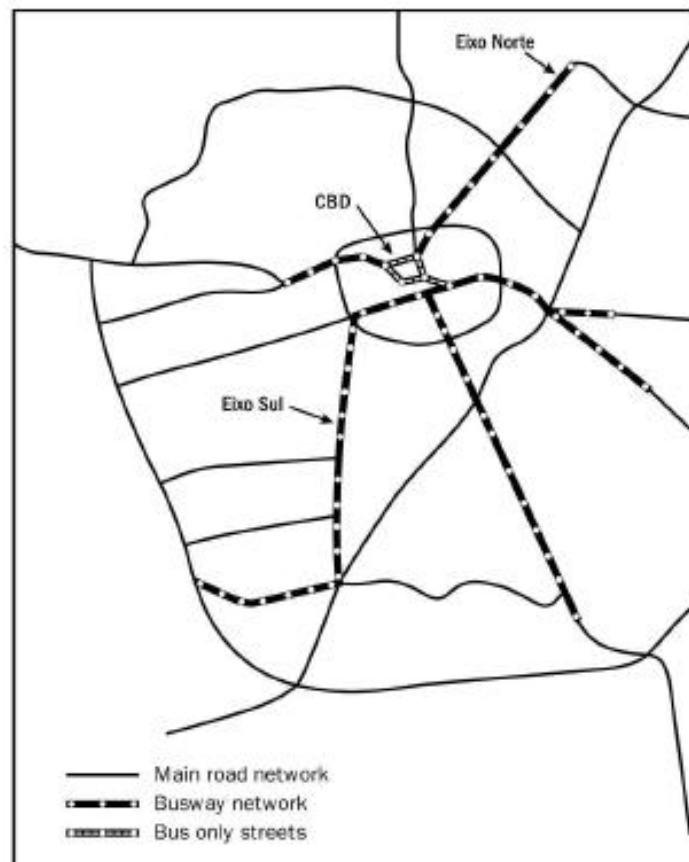


Figure 2.4: Curitiba's System of Bus Services

Source: Levinson, et al, 2003

Decentralisation was a major concern for Bogotá, a city characterised as a low income municipality. In 1998, Mayor Enrique Peñalosa created a mobility strategy to promote urban renewal. The TransMilenio BRT was the centerpiece of this plan. The 2006 Report on the Applicability of Bogotá’s TransMilenio BRT System to the United States asserts that “TransMilenio has raised the level of access between the city’s centrally-located employment centres and the deprived, peripheral areas of Bogotá” (Cain *et al.*, 2006). The implementation of the TransMilenio in Bogotá is a prime example of how BRT and decentralisation can remove congestion. In Figure 2.5, the pictures on the left hand side show the congestion in the city prior to the presence of the BRT, the pictures on the right show the significant decrease in congestion due to BRT implementation. With these results it is not a surprise that decentralisation is one of the preferred methods of having the lines converge within a central business district.

2.4.2 Ridership

Ridership statistics are the primary indicator of a successful transit system, specifically BRT. In the case studies researched, significant increases in bus patronage were reported after the addition of BRT. A study conducted with transit authorities in the western U.S. indicates that

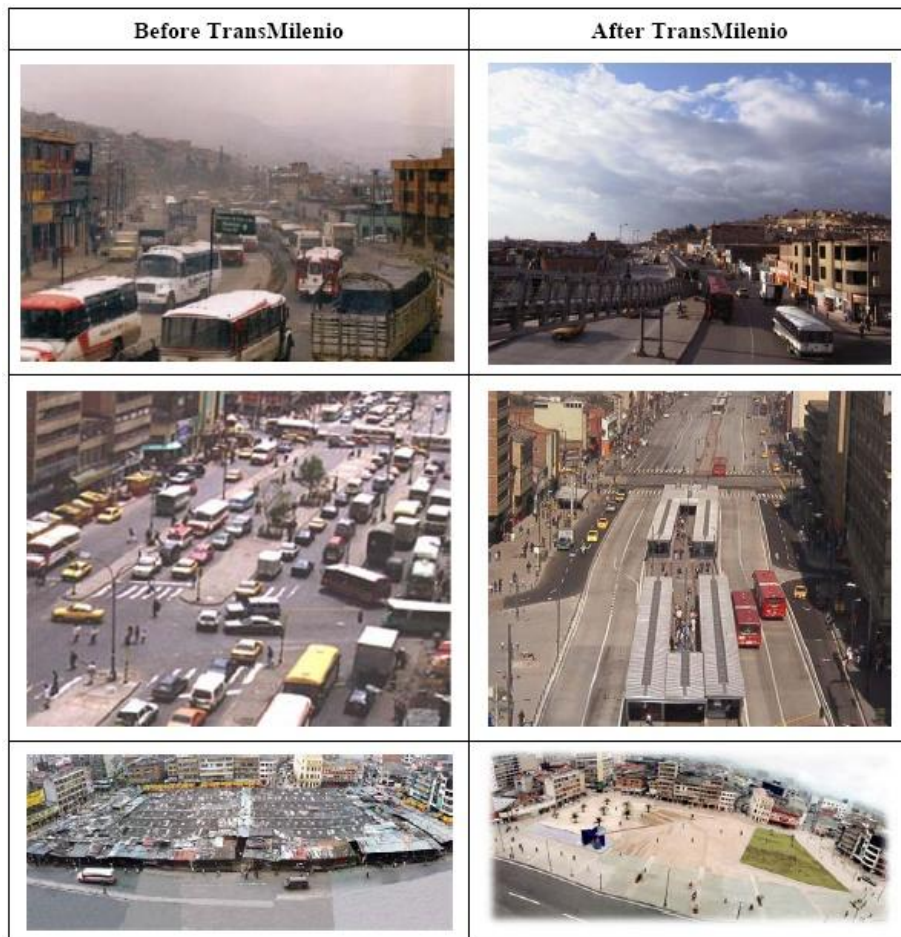


Figure 2.5: Bogotá Before and After the TransMilenio

Source: Cain et al., 2006

implementation of BRT attracted “choice riders,” meaning riders who have other means of transport besides BRT, for example, private car. Authorities claim that BRT has brought more people to use mass transit as a whole. In addition, surveys sponsored by the Federal Transit Administration show that riders prefer modern rail-like BRT vehicles as opposed to former “shoebox” buses. The ridership growth because of BRT is also due to reduced travel times, higher frequencies, improved facilities, and population growth (Levinson *et al.*, 2003).

The following increases in bus patronage after BRT implementation are cited in TCRP Report 90 (Levinson *et al.*, 2003):

- Eighteen percent to thirty percent of riders were new riders in Houston;
- Los Angeles had a twenty-six percent to thirty-three percent gain in riders, one-third of whom were new riders;
- Vancouver had 8,000 new riders, twenty percent of whom previously used automobiles and five percent of whom were taking new trips;
- Adelaide had a seventy-six percent gain in ridership;
- Brisbane had a forty-two percent gain in ridership;
- Leeds had a fifty percent gain in ridership; and
- Pittsburgh had a thirty-eight percent gain in ridership.

The above systems are deemed successful due to the increases in ridership experienced. This increase in ridership proves that BRT in each of these cases is an enticing alternative to private transit. In the above cases, the factors that made BRT enticing were its reliability, efficiency, comfort, and safety. Any new system must fulfill these above requirements to meet the needs of the ridership, and see the patronage shift that proves the system a success.

2.4.3 Public Participation

Citizens who live in the surrounding area of a proposed BRT often show resistance to the change. Even in cases where the current system is obviously inadequate and ineffective, opposition to the plan will most likely occur. In most cases, this resistance is due to the fact that people familiar with the current system are not prepared to change their daily routines.

In Honolulu, citizens expressed opposition to the proposed creation of dedicated lanes while in Guayaquil residents were not comfortable with the proposed distance between the bus stations. It is important that resistance like this be dealt with effectively to ensure the success of the given system. When Honolulu, for example, began to experience such hostility towards their proposal, they made the decision to reach out to the community for their input. Officials held over one hundred public meetings and took input from over one thousand residents. This input led to the decision to cut back on the number of dedicated lanes that had been proposed and also to the creation of lanes with removable barriers, as seen in the Figure 2.6. These barriers allow for easy removal of the dedicated lane based on the flow of traffic using the vehicle shown in the figure.



Figure 2.6: Example of Removable Dedicated Lane System

Source: Adapted from Cham, et al., 2006

In the case of Gyaquil, officials took a more proactive approach to dealing with the community outcry. They heard that citizens were not comfortable with the distance between stations as they were more familiar with flagging down buses and not having specified drop-off locations. After hearing this they decided to rework their plans, making stations 400 to 500 meters apart, creating less distance between stations. This sort of outreach is a crucial part of BRT planning.

2.4.4 Dedicated Lanes

One of the signature features of many bus rapid transit systems is the presence of dedicated lanes. In most cases, these lanes are the two centermost and are set aside for use by the buses within the system. This feature helps to achieve the goal of true “rapid” transport. With these dedicated lanes, those using the bus system never have to wait in traffic and in turn will find a significant decrease in their travel times. These dedicated lanes help to entice passengers to use the system and in turn are one of the factors that lead to the success of BRT. With this being said, dedicated lanes are not right for every route in every system and careful consideration must be given to the unique needs of each route.

In Bogotá, dedicated lanes, as shown in Figure 2.7 have proven to be extremely beneficial. The system provides two dedicated lanes in each direction. The inside of the two lanes is dedicated to local service while the outer lane is express service. This two lane service



Figure 2.7: Dedicates Lanes in Bogotá BRT

Source: Cain, et al., 2006

shown in Figure 6 allows passengers to bypass many of the stops in the centre of the city by taking advantage of the express service. When compared to light and heavy rail systems, the travel times found on the BRT system in Bogotá are significantly less (Levinson *et al.*, 2003).

Honolulu had a much different strategy when it came to dedicated lanes. The major resistance from the citizens led officials to significantly scale back their plans for dedicated lanes, especially in the central business district. In Honolulu, dedicated lanes are found mostly on the freeways that lead to and from the CBD and not in the CBD itself. This is due partially to the fact that constructing dedicated lanes in the already highly developed business district of Honolulu would be nearly impossible. In the CBD, there isn't enough room for the necessary infrastructure, and such construction would adversely affect the already congested traffic situation.

The inflexibility of dedicated lanes can be an inconvenience, especially in developing areas. Though in most cases, dedicated lanes are extremely beneficial, they are also very restricting. In a developing country or city, the needs of the passengers can change over time as new areas of the city begin to thrive. In the typical bus system, the routes can easily be changed with little or no cost. In the case of dedicated lanes, however, the investment is greater so it is much harder to justify altering the routes. This is not to say that dedicated lanes are not successful; instead it is important to fully analyse the use of dedicated lanes to ensure they fulfill their potential and don't become a wasted investment.

2.4.5 Stations

Stations are a key component of the both BRT function and image. BRT systems utilise decentralised stations much like a metro system to have efficient drop off and pick up of passengers in a timely manner. Planners strategically place stations so that they will serve the most individuals possible, increasing efficiency and decreasing the number of stops. Stations also serve another role, however. They are seen as gathering areas, and because of this, certain services are needed to make them accommodating.

Architects and planners of the BRT systems have faced the challenge of revamping the image of bus transit. Innovative station design is one technique for dealing with this image. In many of the BRT systems worldwide, their stops are unique and visually appealing. The BRT stations in Curitiba are known for their tube like structures. Similarly, their buses have vibrant colors that make them stand out in traffic and create a positive, clean image. In Brisbane, the BRT stations are modern and contain intricate architecture which creates an identity for the system, as seen in Figure 2.8. In these modern stations, riders find many amenities such as newsstands, vending machines, and restrooms. Vandalism can be an issue, though, in stations with such added amenities. The use of security cameras and guards are solutions to this problem used in many cities.



Figure 2.8: BRT Station in Brisbane, Australia

Source: Levinson, et al., 2003

The placement of the stations also needs to be well planned. The major factors taken into account when planning placement of stations are population density, accessibility, integration, and stop spacing. Outlying stations should be accessible by private motor vehicles and should have parking lots for riders. These stations should be placed in the densest population areas and should have climate appropriate enclosures. The typical spacing between stations ranges from 1250 to 3000 meters.

Main Arrival Mode	Spacing (km)
Pedestrians	0.400 - 0.550
Bus	0.800 – 1.600
Automobile	3.000

Table 2.2: Typical BRT Station Spacing

Source: Levinson, et al., 2003

Table 2.2 shows a comprehensive breakdown for determining station spacing, and although these are typical, certain situations can dictate different spacing. When BRT stations are placed in commercial locations, walking distance and mass transit integration are among the top deciding factors for placement. In the CBD, location of the stations is also based on the highest demand of the riders, including entertainment venues and large commercial locations. If stations are not properly placed they are less likely to be used, in turn, causing the system to suffer.

The physical location of the station depends on the design of the BRT system as well as the length and loading height of the buses. A majority of the BRTs worldwide utilise a median system where the buses travel between the opposing traffic lanes, and utilise up to twenty-two meters of the median. This allows for two loading lanes at the station and typically a bypass lane. Figure 2.9 shows a typical median station layout.

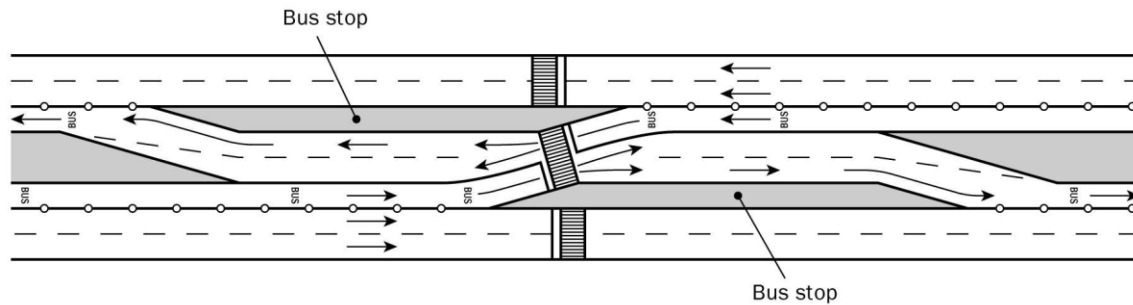


Figure 2.9: Median BRT Station Layout

Source: Levinson, et al., 2003

Bus rapid transit stations are also designed based on the buses that will be utilised for the BRT system. The popular choice is articulated, low floor buses which are being utilised in a wide variety of BRT markets due to their versatility and capacity. With these buses, the station loading platform is lower, allowing for less of an elevation change and more accessibility to the station. With the lower loading platforms, passengers commonly attempt at grade level crossing between bus travel lanes, which is dangerous. Municipalities have resorted to using fences between bus lanes to discourage this practice. Crossing is allowed at elevated pedestrian bridges or in designated crosswalks that are timed with bus activity.

A popular feature in the BRT stations is the introduction of Intelligent Transportation Systems (ITS). ITS allows for real time interaction between buses and riders. In Los Angeles, for example, the BRT system stations are all equipped with light-emitting diode (LED) readouts of the arrival time for the next bus. This advanced feature improves the riding experience for the passenger and allows for worry-free transit to his or her destination.

2.4.6 Fare Collection

One of the major goals of bus rapid transit is to facilitate faster boarding times. The fare policy and collection mode play a vital role in this process. This policy should be designed with passenger convenience as a primary concern. Bus dwell times are also important to consider and these topics will be discussed below

During peak hours and at major boarding stations, off-vehicle fare collection has proven to be effective at reducing station dwell times. At off-peak hours and low volume times, on-board fare collection may minimise unnecessary operating costs. However, in cities where BRTs have been implemented “low-volume times” are unlikely (Levinson, *et al.*, 2003).

Currently, most cities are using on-board collection through an electronic fare box, seen in Figure 2.10. Passengers have the option of paying cash or using a prepaid card. While this method is convenient for passengers, bus dwell times suffer.



Figure 2.10: Electronic Fare Box

Source: Metro, 2007

Many cities have made plans to include off-vehicle collection at specific stations, if not all. The preferred payment would then be a SmartCard, like those used in Bogotá and shown in Figure 2.11. With SmartCards, fares are paid upon entering the station and no additional transfer ticket or payment is needed. This system allows for simultaneous boarding and reduced dwell times. In Curitiba, boarding times were reduced by an average of twenty seconds with these cards (Levinson, *et al.*, 2003). In some cities, SmartCards may not be feasible due to operational costs and passengers may find them inconvenient to purchase and recharge. The trade-off between bus travel times and customer convenience must be carefully considered in fare collection planning.



Figure 2.11: Smart Card Technology

Source: Cain, et al., 2006

2.4.7 Route Planning

The planning of routes of a BRT is one of the most important aspects of the early development stages and requires the most attention. When routes are decided, a number of important factors come into play. The routes must be easily accessible to the greatest number of riders. They should parallel or cut through high density areas to increase ridership, and should be integrated with other forms of transportation for the most successful outcome.

If a route in a BRT system needs to be shut down, the process is easily facilitated. As opposed to rail transit where miles of iron track, complex stations and many road crossings would have to be removed or adjusted for the stop in service, a BRT route is very easy to disassemble. In the case of Honolulu, a year into the system their fifth route, Route E, was experiencing considerably less ridership than they had predicted. They came to the decision it was not cost effective to continue this branch of the system. To discontinue the service they simply moved the buses from Route E to the other routes in the system. The route was cut off with little loss of upfront investment and very little additional cost. This flexibility in the routes of the BRT is even seen in the design of the stations. In some cities, while experimenting with new routes, they will use modular stations or stations that can easily be built and removed, making the entire system more versatile.

This versatility of the BRT system is very attractive to city planners, especially those of young and developing cities. In some cases, a BRT is used as a stepping stone to a more established rail system. BRT routes can serve as experiments for a later rail line allowing for planners to easily edit the routes that cross the city with little repercussions and no permanent infrastructure. This versatility also allows for eventual changes due to population shifts, rezoning of commercial or residential land, or natural disasters.

2.4.8 Privatisation

Privatisation can be defined as the act of shifting the government or public's control into the hands of private companies. Privatisation has many benefits and has the advantage of providing the needed capital investments. For example, Guayaquil has a bus system, the Metrovia, which is a public-private partnership. The system is subsidy free and overseen by three groups working together to create a successful bus operation. The City established a small foundation of twelve employees who are responsible for administration and regulation. There is also a private company managed by the City-appointed foundation, to provide bus operations and fare collection services. This same private company also owns the infrastructure and sets up contracts for the drivers of their buses. All revenues are placed into a trust, and then dispersed to the appropriate agents (Buchwald, 2007). This level of financial freedom affords the Metrovia independence from the fluctuations in city politics.

With all these elements in place, Guayaquil has successfully presented a model for sustainability in the area of public transportation. In most cases, private companies immediately begin under contracts and provide capital for the government to maintain its bus operations. There have also been cases where privatisation has been a disadvantage to a bus system and hurt not only the passengers but the City's economy as well (Golub, Hook, 2003). Under privatisation, some companies have the freedom to operate the only bus transportation system in the city. The goal of the company is to make a profit and often company decisions disregard how the city and its people are affected. An example of this may be unprofitable routes due to lack of ridership. The company will not have its buses travel to these locations, forcing passengers to find other ways to their destination. A lack of affordable and efficient

transportation may cause an inverse in the use of private cars and an immense increase in traffic flow, as is the case in São Paulo. The City of São Paulo has recently tried to control the monopoly that the private companies have on transportation operations by having them sign contracts requiring the operation unprofitable routes, with the government subsidizing the difference in costs. Initially, the contract was written to pay per person; however, after reexamination, this led to an increase in government spending thereby, increasing taxes. When the companies were approached to change to being paid by kilometre instead, they refused. This would have led to a loss of profits, a change not welcomed in the corporate world. With this predicament, the government was forced to increase fares, leading to a decrease in ridership.

Private companies can be very difficult and complicated to control. There are many alternatives to using a system of privatisation. One example is creating a semi-private organisation to manage transportation operations such as Honolulu. As discussed in previous sections, the City of Honolulu developed a non-profit organisation to handle its bus operations as opposed to using a private company.

Privatisation can be both an advantage and disadvantage. It can also be difficult to manage, as is the case of São Paulo and may cause the city huge setbacks and loss of ridership trust. It is important when deciding on whether privatisation is best for a system that all these aspects are taken into consideration.

2.5 Summary

Through our research we have looked into the various BRT systems of the world, analysed the features of each system's operations, investigated the issues surrounding each system and have drawn lessons from each that we feel can be applied to a BRT in Cape Town, South Africa. We have identified eight unique factors that go into the planning, implementation, and maintenance of a successful bus rapid transit system. With these factors considered, the development of a strategy for the creation of an appropriate bus rapid transit can move forward.

3 Methodology

The ultimate goal of our project was to identify the needs of bus passengers coming into the Cape Town CBD daily along the Culemborg Corridor, shown in Figure 3.2, and devise a plan for effectively meeting their needs as the route passes through the City. This project contributes to the overall integrated transportation plan for the City of Cape Town. The vision of this large scale plan is “to provide a world class sustainable transport system that moves all its people and goods effectively, efficiently, safely and affordably” (Integrated Transport Plan for the City of Cape Town, 2006). Our project obtained information on BRT case studies around the world by identifying lessons which have been learned in each system. We also gathered data on the ridership heading into the CBD. From this research, we were able to develop a plan for the infrastructure around the CBD for bus routes entering from the Atlantic Seaboard. The flow chart of the methodology we used is shown in Figure 3.1 and the timeline of our project shown in the form of a Gantt Chart is shown in Figure 3.3.

Our project took place in Cape Town from October 22nd, 2007 to December 12th, 2007. While in Cape Town we looked at the needs of the ridership through an origin-destination survey. We organised the results into visual charts and maps. Simultaneously, we compiled information on BRT station designs through the creation of a station design manual. At the end, we presented a report containing our final on-site feasibility analysis for the Cape Town CBD to our sponsor. This chapter addresses these topics in the following order: Collection and Comparison of BRT Station Designs, Origin-Destination Survey, Organisation and Mapping of Survey Data, and Routing and Station Design.

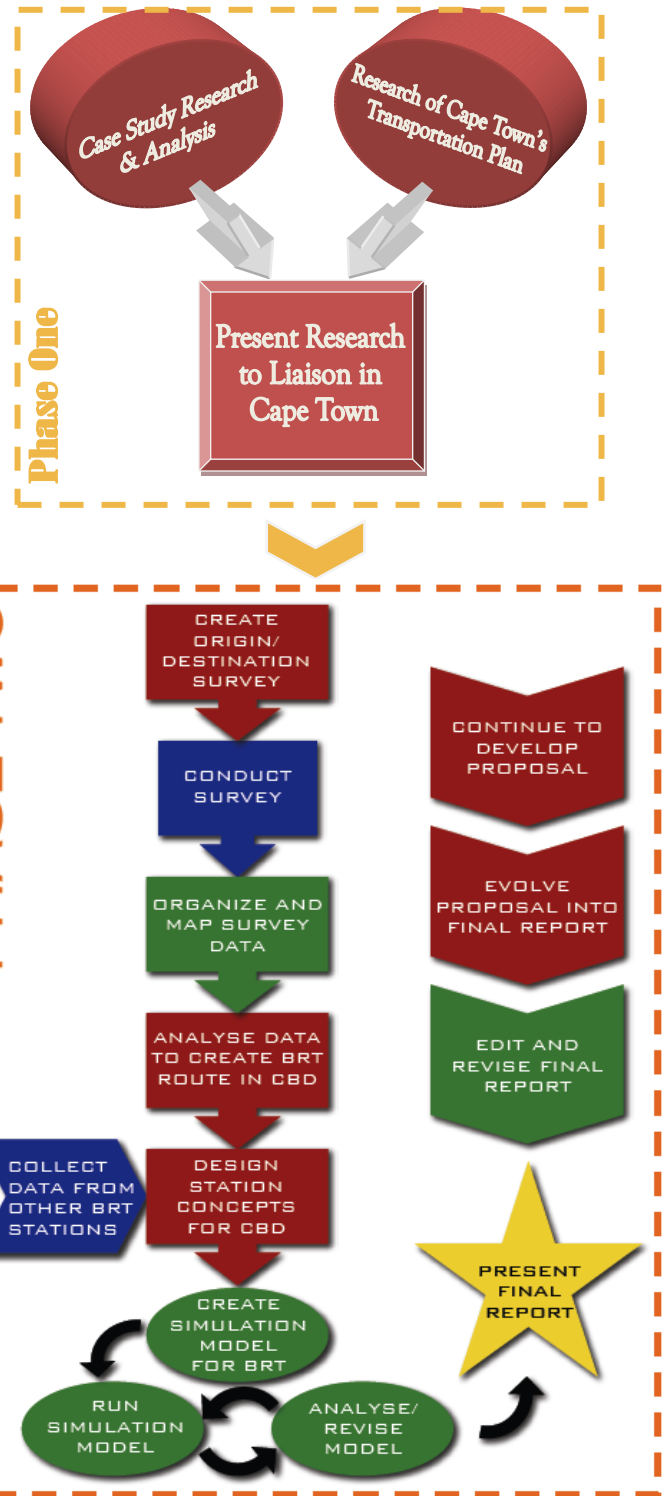


Figure 3.1 Methodology Flow Chart

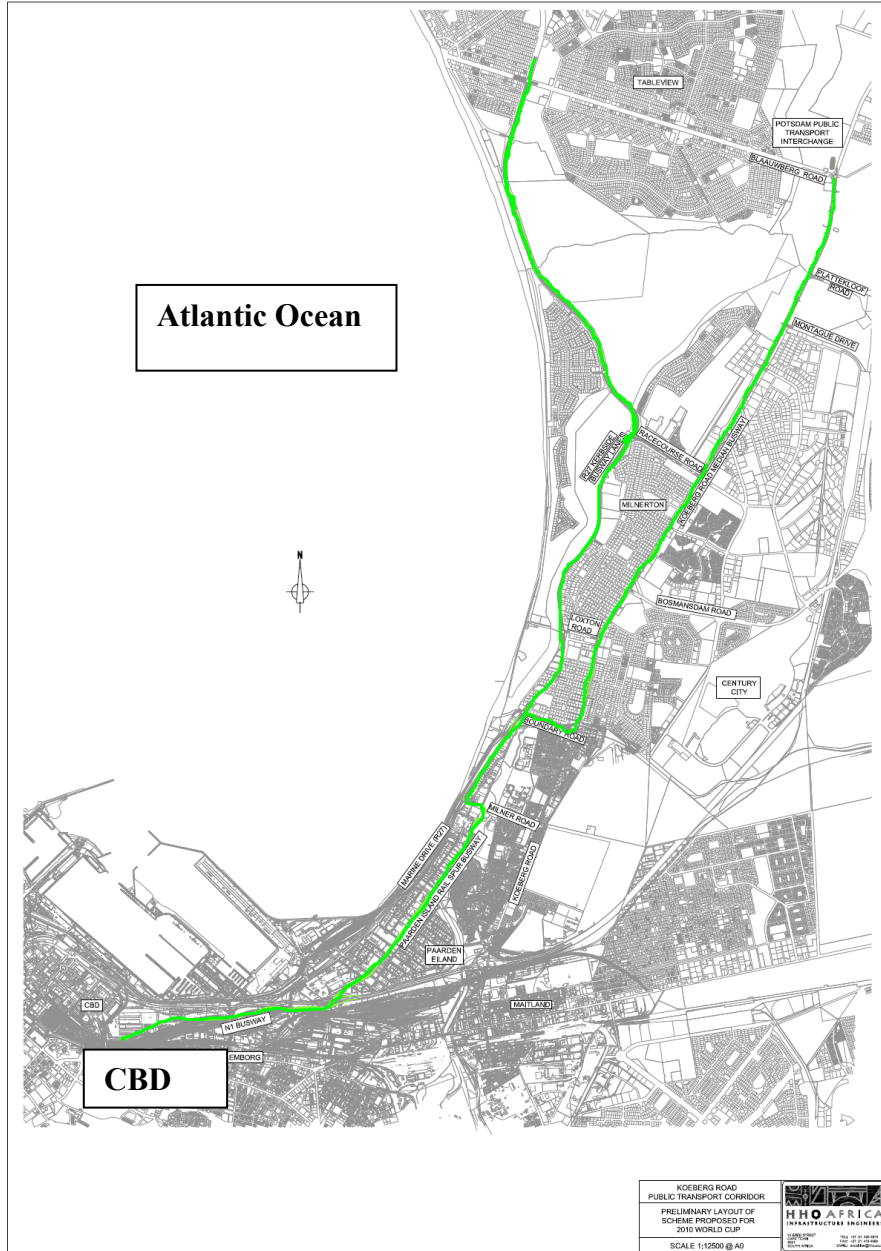


Figure 3.2 Aerial View of the Proposed Culemborg Corridor

Source: HHO Africa, 2007

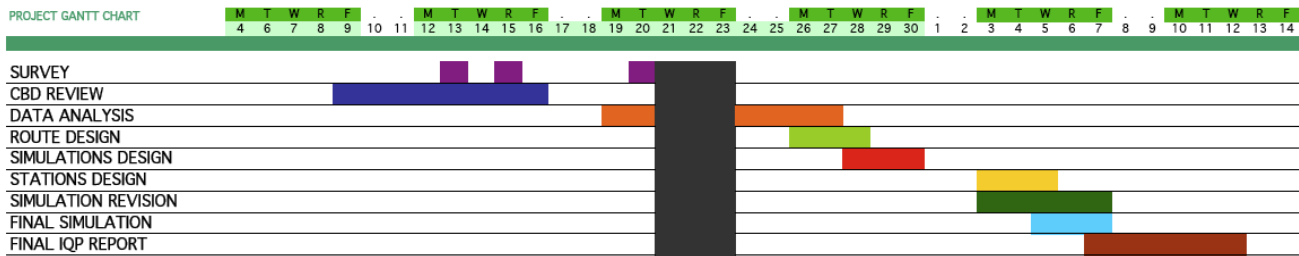


Figure 3.3 Gantt Chart of Project Tasks

3.1 Collection and Comparison of BRT Station Designs

In order to organise the varied station designs found through our research, we developed a Station Design Manual found in Appendix C. This manual was necessary because it contains both advantages and disadvantages of a variety of station designs. The manual looks at both large-scale terminal BRT facilities as well as smaller roadside stations. For each location, the team evaluated the advantages and disadvantages of the designs in order to identify best practices. We also toured many of Cape Town’s current transportation hubs and observed the characteristics that past design teams have identified as important for the City’s commuters. Through both of these evaluations, we were able to begin to identify features that are important in BRT station designs.

3.2 Origin-Destination Survey

In order to properly plan the BRT routes in the CBD we needed to conduct an Origin-Destination Survey (ODS). The ODS is important because it looks at the starting point of a passenger’s trip using the existing mass transit modes (buses or minibus-taxis) as well as his/her final destination. We list some of the critical questions below; a complete survey is found in Appendix D.

- *Where did you board public transportation and what time?*
Nearest Street Intersection: _____
Time: _____
- *Where do you get off public transportation?*
Public Transport Destination/Nearest Intersection: _____
- *What is your final destination?*
Nearest Street Intersection: _____
- *How do you get to your final destination after getting off public transportation?*
- *What is your major complaint about public transportation?*

This information was necessary to effectively plan routing within the central business district. The survey also delved into the modes of transport used daily as well as asking for passengers’ main complaints with the mass transit in the city. Identifying the needs of the passengers was crucial to developing our final model for the corridor.

Alongside members of the City of Cape Town’s Department of Transport, we conducted the origin-destination survey over the course of three weekdays during the morning peak period (0600-0900). We boarded both buses and minibus taxis in Atlantis, Dunoon and Potsdam and asked the passengers individually the details of their journey. In order to carry out this survey,

explicit permission from Golden Arrow Bus Services was obtained by drafting a letter of intent. Authorisation for all individual minibus taxi drivers was received before each survey was conducted. In most cases, there were barriers that delayed the process of surveying. These obstacles were mainly reluctance from minibus owners, time restraints, and language barriers. We were able to resolve some of these problems by requesting Xhosa translators and additional surveyors during the peak hours.

3.3 Organisation and Mapping of Survey Data

Upon completion of our inquiry, we compiled the approximately two hundred surveys and logged the results into a Microsoft Excel spreadsheet. We used the pivot table feature of Microsoft Excel to allow for easier analysis of the data. Once inputted, the data were manipulated to show passenger alighting trends throughout the central business district and surrounding areas. Once reviewed, the data were displayed in various graphs to show their distribution for several variables. In order to better group the data, we devised a set of areas into which we grouped the final destinations shown in Figure 3.3. This allowed us to find trends in certain zones of the City, as opposed to along individual streets. After compiling the data, we then mapped every passenger's beginning and end points with the help of John Spotten from the Cape Town Department of Transport. We used GIS mapping to show destination concentrations within the CBD. Different size circles were used to represent the number of passengers at each destination. Each circle was then divided into different colors representing the origins of each of the passengers. With the completed map, we were able to identify various trends in the movements of the passengers.

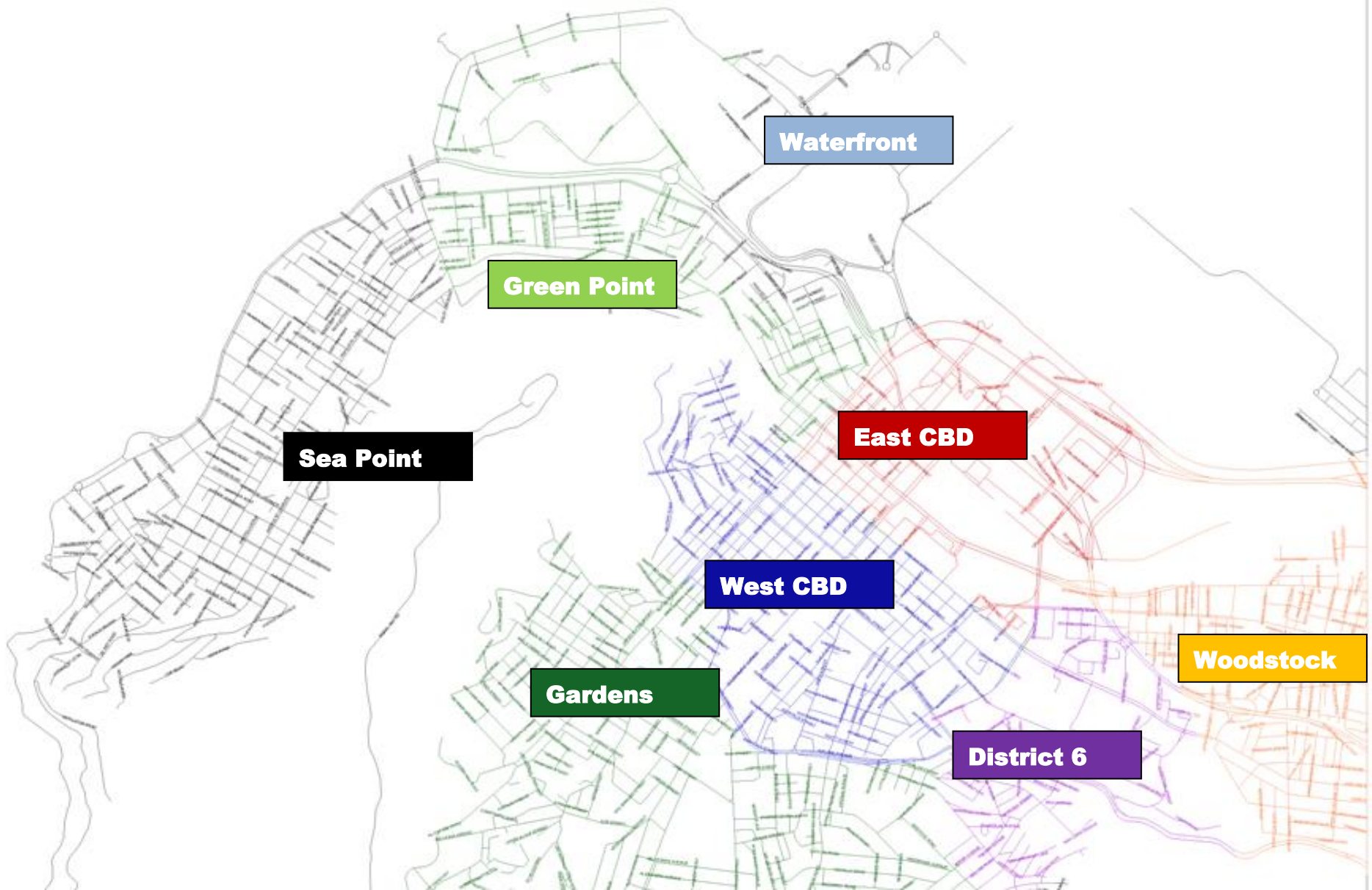


Figure 3.4: Zoning of the CBD used for ODS Analysis

3.4 Routing and Station Design

There were a multitude of steps that went into the creation of the final design. The flow chart in Figure 3.5 shows the components of our decision making process.

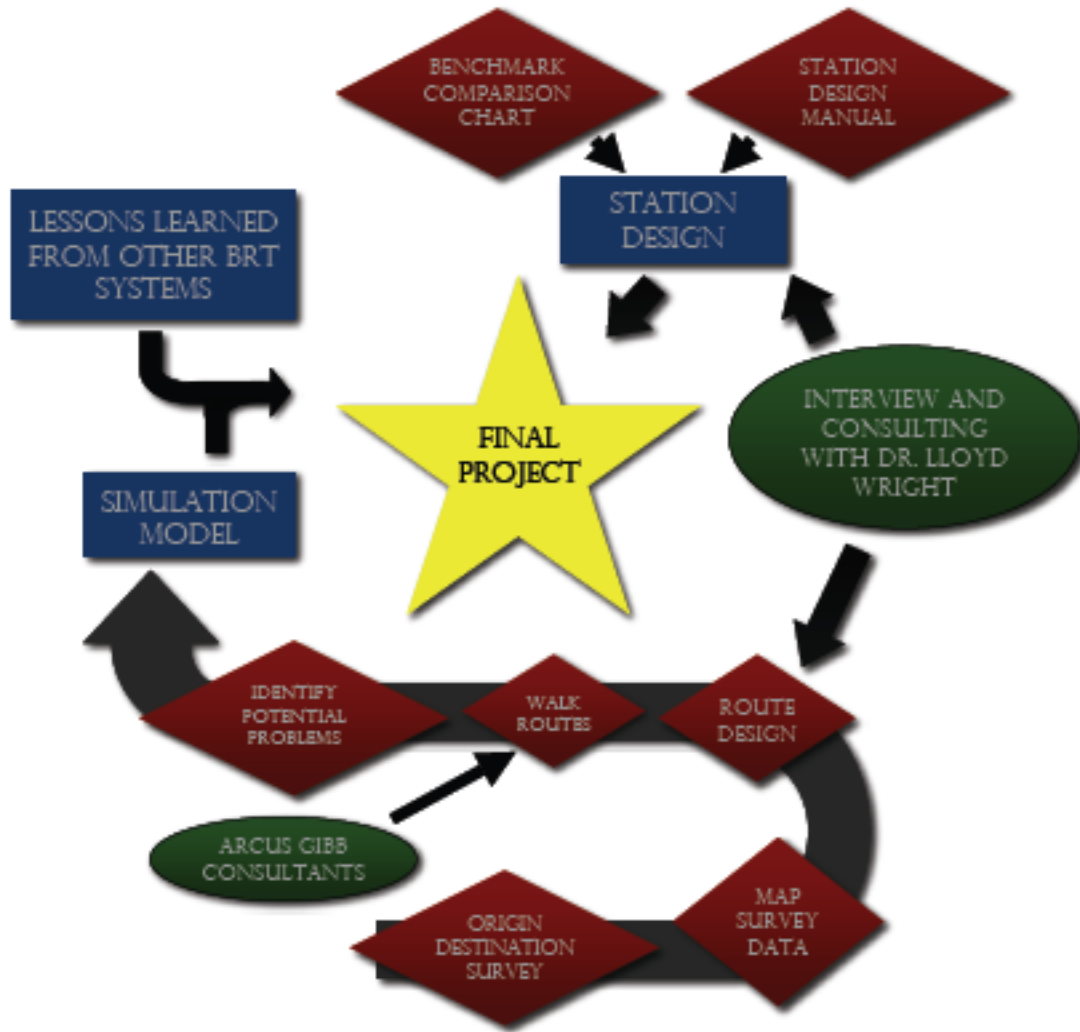


Figure 3.5: Components of the Final Project

Each of these components was necessary in the completion of the final design. The interviews we conducted with Dr. Lloyd Wright, BRT Operations Planner, and Fredrick de Villiers from the consulting firm HHO Africa were crucial in the development of our routing and station design because they helped to clarify the City's plans for BRT.

Using the GIS mapping, we developed routing within the CBD that best met the destination needs of the passengers. The aim was to cover destination demand within a 500 metre radius. We then presented this routing to our liaison, Gershwin Fortune, to get his feedback.

With a finalised routing, we began to identify locations along the routes where we thought stations would be necessary. Prior to going out and viewing the potential sites, we

developed a preliminary station design which took into consideration safety, aesthetics, efficiency, and cost. To develop this design, we had to make decisions about kerbide versus median placement, as well as closed versus open stations. We used a benchmark comparison chart to compare the designs against each other. Each objective was weighted on a scale of one to three based on its importance. With this chart we were able to identify which design best fit the objectives we set out to achieve. In addition to these two main decisions, we picked out the best practices from all the stations we researched and combined them with factors we knew were important in the City of Cape Town.

With a preliminary design completed, we developed an on-site feasibility analysis by walking the route we had proposed and assessing the station locations in order to evaluate the land available. We identified the difficulties that might be encountered, and then developed potential solutions for these difficulties. In the end, we were able to comprise a final plan which consisted of routing, station location and station design for the Culemborg Corridor as it enters the CBD.

4 Results and Analysis

The project goal was to use the information collected from our research to create an on-site feasibility analysis for a BRT entering the Cape Town CBD from the Culemborg Corridor. In this section, we show how we organised our survey information based on the passengers' origins and destinations, and state the assumptions that were made for the analysis of the ODS data. We detail the routes we developed to optimally cover the range of daily passengers and where stops are needed. Our approach in the decision-making process is described as well as our results. Finally, the advantages and disadvantages of all the scenarios we considered, and how they fit into the City's plan for addition of further routes in a later phase, are laid out.

4.1 Origin-Destination Survey

The origin-destination survey results contained information which we used to plan the dispersal of passengers and adequately provide the number of BRT routes needed along the Culemborg Corridor. After riding the bus and asking the questions, the team discussed each surveyor's trip into the City and the lessons learned about current bus operations. Two prominent issues impacting the future BRT system emerged. Currently, there are many empty buses traveling to the City daily on routes that can be consolidated to ensure infrastructure is being used effectively. Furthermore, a majority of the passengers who do get off in the city do not depart at the Golden Arrow Terminal. Instead, these passengers disembark from the bus in a decentralised fashion as the buses approach the terminal, in order to get to their desired destination. This observation supported our plan to create decentralised routing within the CBD. Having identified these two issues, we are able to take them into consideration in our routing. As part of our survey, we also collected information regarding passengers' most common complaints about the current mass transit system. Passengers were asked what their biggest qualms were with the current system. The distribution of issues is shown in Figure 4.1.

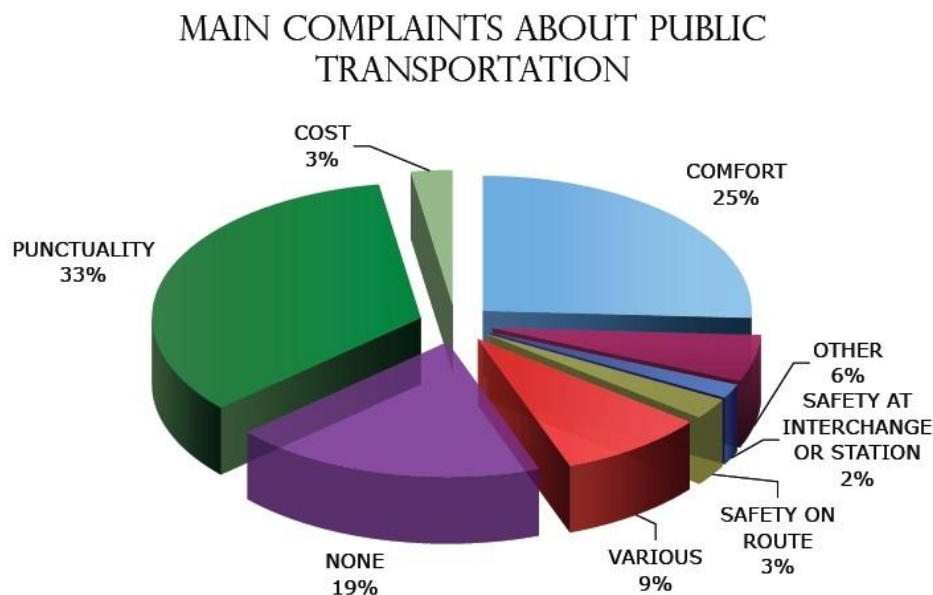


Figure 4.1: Major Complaints about Public Transportation

The results showed that there was an overwhelming problem with punctuality of the buses or minibus taxis. We found that passengers, especially those travelling by minibus taxi, wait for long periods of time at the terminal. When we were in Dunoon, there were very long queues with wait times up to forty-five minutes for a minibus taxi. For the bus passengers, the major complaint was punctuality, but for different reasons. Passengers said buses were never on time, making it hard to gauge when to be at the stop. In most instances, the buses would come early and not stop, leaving passengers to wait for the next bus.

In Figure 4.1, the category “Other” included the following complaints:

- Buses are old and falling apart
- Fare is too expensive for services provided
- Drivers can be reckless and do not care about passengers

The category “Various” refers to passengers who had more than one complaint about the system. These were often a combination of punctuality, comfort, and safety. With this added information, we were able to develop our project by aiming to alleviate these complaints.

One of our goals was to identify the percentage of ridership heading into the CBD in comparison to the percentage of ridership heading to the areas outside the CBD, such as Sea Point and Green Point. The locations of these regions are shown in Figure 3.4. The colors of the regions shown in Figure 3.4 correlate with the colors found in Figure 4.2.

Roughly sixty percent of all public transportation riders on the bus routes surveyed were travelling to a destination within the CBD and just under ten percent of passengers were heading in the direction of Sea Point. In addition, through our daily use of the system, we identified that there are many individuals who travel from the CBD to Sea Point everyday who are not represented in our data. We recognized that continued service into Sea Point would benefit these passengers as well.

PASSENGER DESTINATION BY AREA

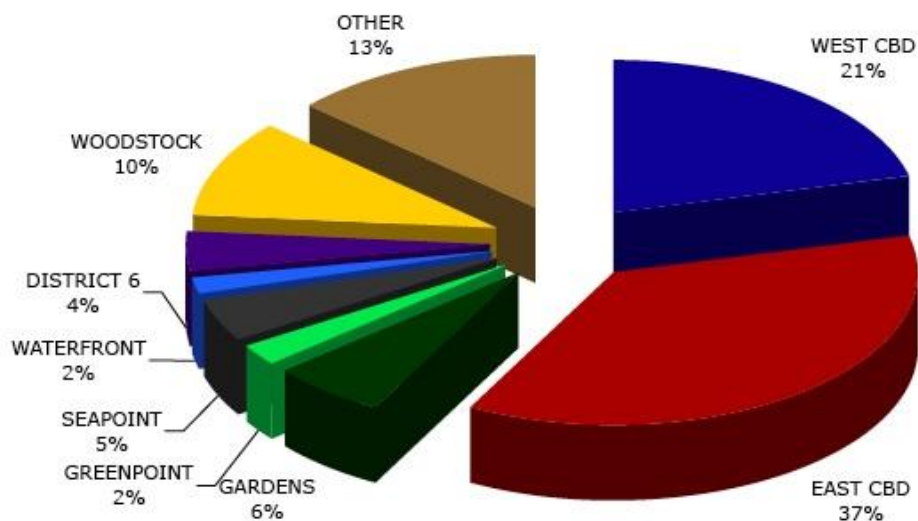


Figure 4.2: Passenger Final Destination by Area

After analyzing the data, each end destination was plotted on maps using GIS in order to visually identify destinations. Figure 4.4 highlights the current routes along the Culemborg Corridor in which lines coloured light blue, blue, light green, red and purple represent the routes surveyed as the buses approach the central business district. Figure 4.5 and 4.6 show the passengers' destinations in the Cape Town CBD by using circles of different colors and size. The legend used in these three figures has been enlarged and shown in Figure 4.3. The circles vary in composition of yellow, red, blue, purple and light green. These colours represent the origin of the passengers' surveyed and correlate to the colours shown in the bottom of the legend. The size of the circle is determined by the number of passengers alighting at that location. The three circles shown in the legend give examples and correlate to specific numbers of passengers for comparison. It is important to note that each destination was labeled and the numbers that appear within the three figures simply serve to the destination labels.

Sample Routes

- Atlantis_Bus
- DuNoon_Taxi
- Killarney_Bus
- MarineDrive_Bus
- Potsdam_Bus

CBD Destination Locations of Occupants of Sample Bus/Taxi Routes along West Coast

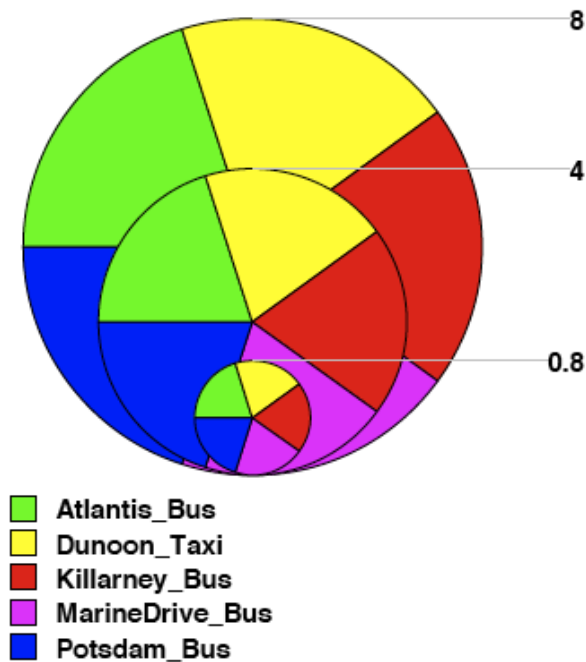


Figure 4.3: Legend of routes, origins, and passenger quantities

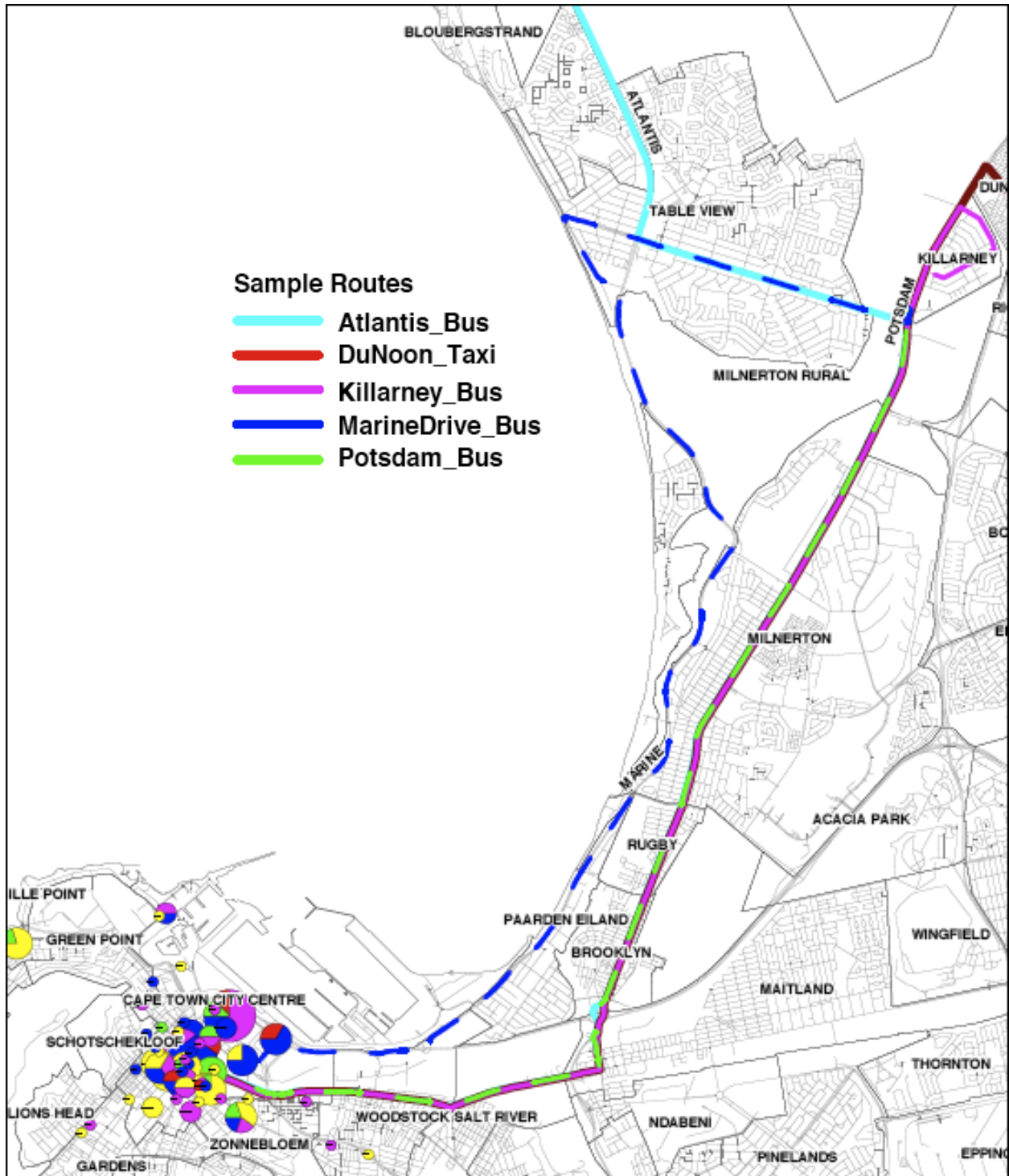


Figure 4.4 Surveved Routes in the Culemborg Corridor

Produced with help from John Spotten, Cape Town Department of Transport

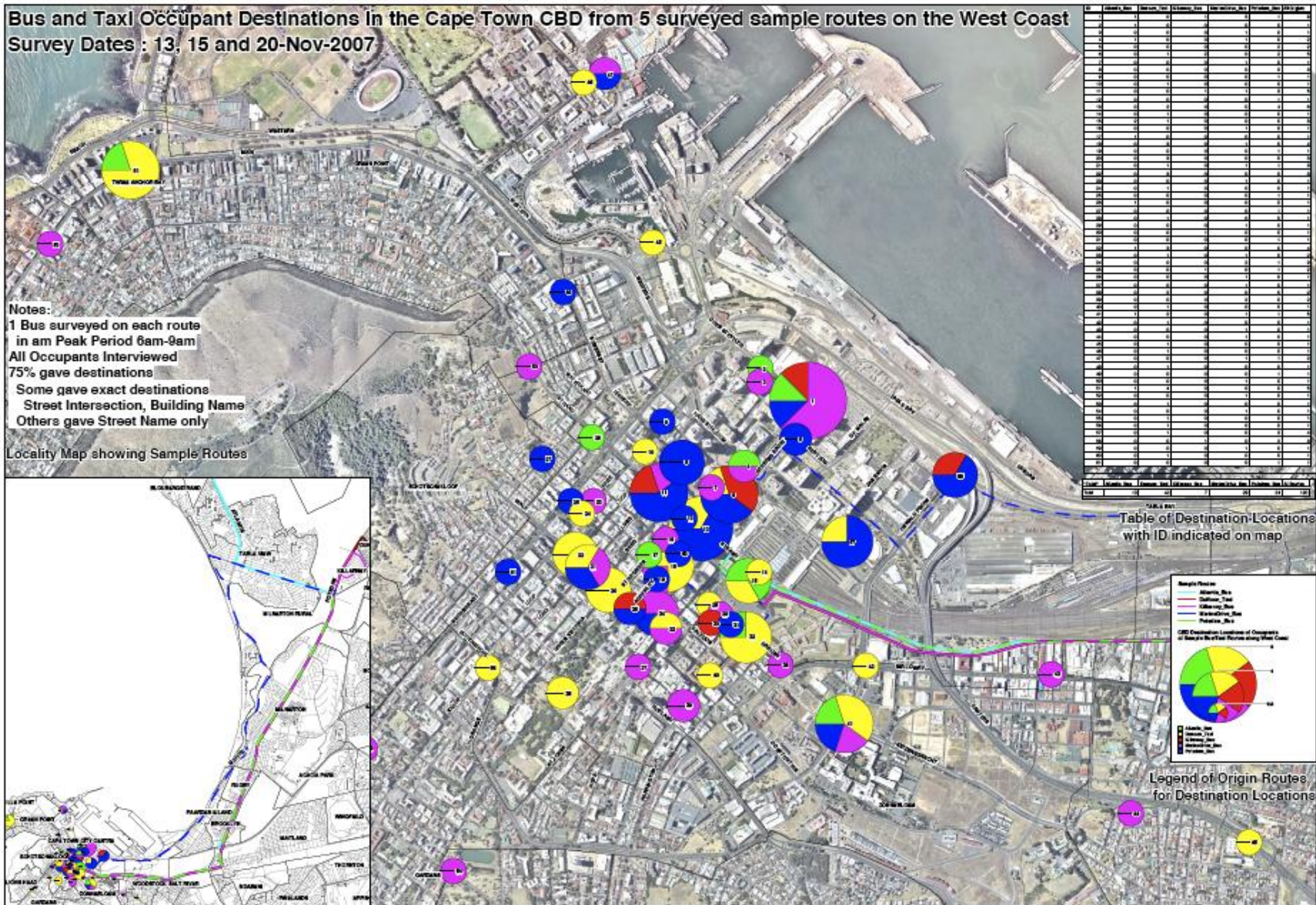


Figure 4.5: GIS Mapping of Passenger Destinations

4.2 Route Planning

Upon completion of data collection, we began mapping potential routes. We identified the streets within the CBD that have a large volume of passengers alighting. Using this information, routes were planned in the central business district which achieved the following:

- Met passenger demands found in Figure 4.6
- Followed decentralised loop incorporating the “SuperBlock”
- Addressed the need for routes that continue on to Sea Point
- Met 2010 World Cup needs
- Fell on streets capable of having a dedicated lane

Preliminary route plans were drawn out with the goal of covering streets with the largest volumes of passengers alighting. The volumes of passengers are represented by the yellow circles in Figure 4.7. These streets included Wale, Adderley and Long. The routing was then modified because they were too narrow to accommodate BRT lanes. ODS data also showed that about ten percent of passengers continued onto Green Point, the Waterfront and Sea Point. A route was planned, shown in blue, which went straight up Hans Strijdom Street onto Western Boulevard to address this need. Also, during the World Cup in 2010, Cape Town will see an increase of passengers going to Green Point and the Waterfront. Having these routes in place will accommodate the anticipated demand.

An important aspect of the route plan is that it is in one direction. The red route in Figure 4.7 is a loop around the CBD that returns up the Atlantic Corridor. This route is designed as the termination of a line-haul route and does not address the needs of passengers in the CBD who want to get to other areas in the City. Where the route enters along Old Marine Drive, it passes the main rail, bus and minibus taxi interchange which allows those individuals who need to transfer to do so. While creating these routes we recognised that additional routing will be necessary in a second phase to truly meet the needs of every passenger. The routing we have designed brings eighty percent of passengers within 500 metres of their destination. The routing was designed with the goal of making the addition of future routing easy and seamless.

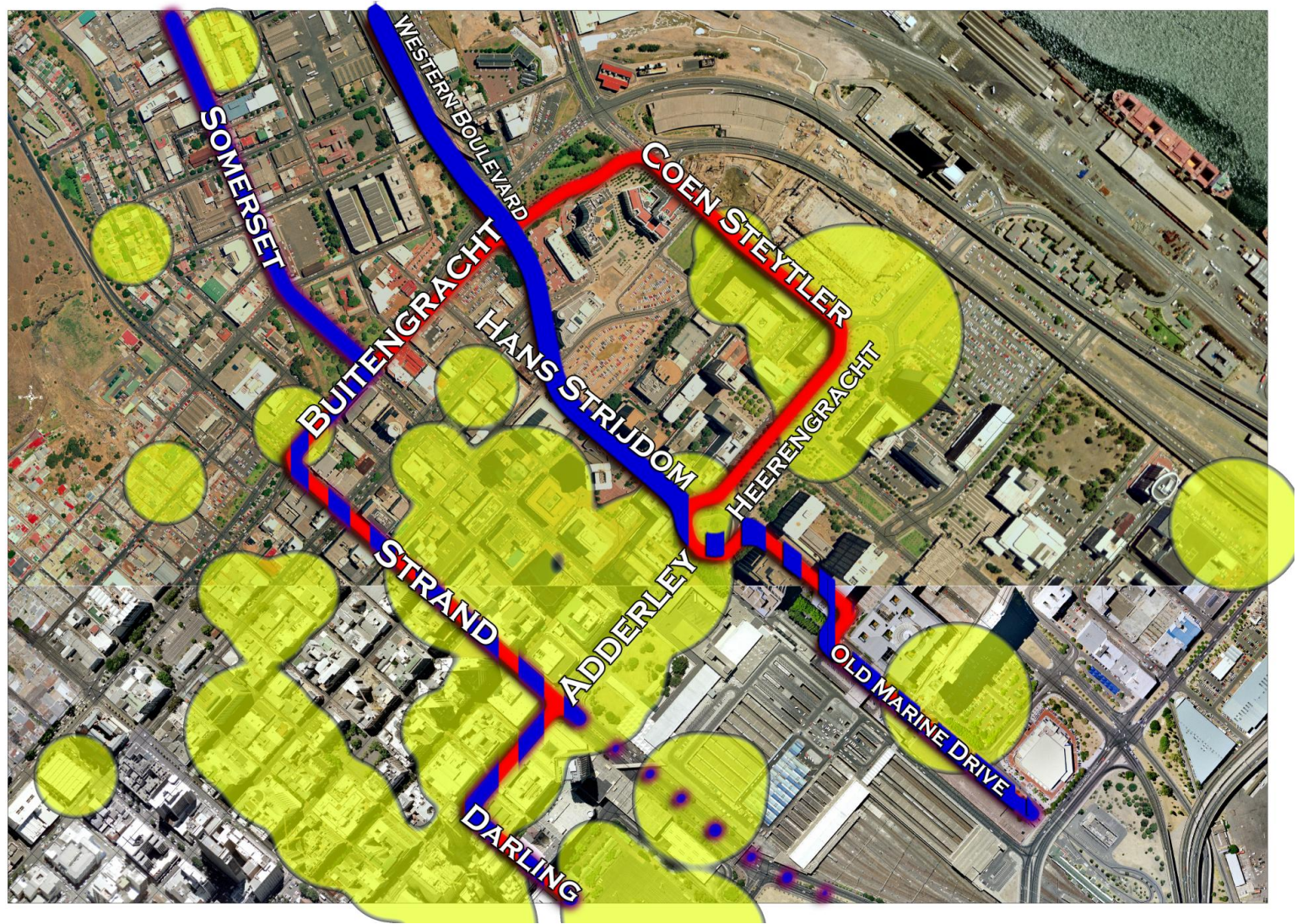


Figure 4.7: Routing Design

4.3 Station Design

With the completion of our ODS analysis and routing design, we were ready to begin looking at possible station designs. We had found that there are three major decisions that needed to be made in order to properly begin planning the BRT stops within the CBD. One was fare collection. The facilities necessary at a given stop are defined by the way fares are being collected. In this case, we were instructed by our liaison to assume that Cape Town will be using a flat fare system. If the City of Cape Town were to choose a zonal system instead, the fare would be determined by the distance travelled, meaning some of the poorest citizens who live far from the City would be forced to pay the most.

The other two decisions that had to be made were whether the stations would be kerbside or median and closed or open. To do this, we developed a benchmark comparison chart with the four possible scenarios shown in Table 4.1.

Weighted Benchmark Chart

	Weight	Open and median	Open and kerbside	Closed and median	Closed and kerbside
O: Security	√√√	√√√	√√√	√√√	√√√
O: Simple to construct	√		√		
O: Easy to use	√√√		√√√	√√√	√√√
O: Safe for pedestrians	√√√		√√√		√√√
O: Allows for rapid transit	√√			√√	√√
O: Acceptable land use	√√		√√		
O: Protection from weather	√√	√√	√√	√√	√√
O: Connects with proposed corridor	√	√		√	
Totals	19	6	14	12	13

Table 4.1 Benchmark Comparison Chart of Station Designs

Security, safety of pedestrians, and ease of use were identified as our three most important objectives and they each received three checkmarks. Safety and security were identified as among the most important because they are currently major issues within the City and are known for directing an individual's choice of transport. It is crucial that passengers feel safe getting to and while waiting at a stop. The objectives receiving two checkmarks included

rapid transit, weather protection, and acceptable land use. Weather protection is important because there is wind and heavy rain during the winter months. Weather is not a major concern throughout the entire year, though, making it a lesser objective. We identified our least important objectives as ease of construction and seamless connection and they each received one check mark. Though both are important, they are not crucial to the success of the system.

After completing the chart we found that out of the nineteen possible checkmarks, open and kerbside had received fourteen, followed by closed and kerbside with thirteen checkmarks and closed and median with twelve. We identified that this comparison, though it was very useful, was not perfect. We further compared the open kerbside design to the closed median design, and discovered that the closed median design has a multitude of advantages. In particular, this design truly allows for rapid transit with pre-paid ticketing. As shown in the benchmark chart, though, pedestrian safety is definitely an issue with the median design. Traffic in Cape Town is known for being erratic, making travel to the median a dangerous proposal. We were hesitant to say that a median arrangement would fit within the already congested and sometimes quite narrow streets, such as Adderley St. shown in Figure 4.8. Extensive land surveying and traffic studies would have to be conducted before we would feel comfortable proposing such a system.



Figure 4.8: Adderley St.

We decided that open kerbside stations, as in Figure 4.9, were the best proposition for Cape Town. By this we mean the stops will be located on the kerb and passengers will validate their tickets onboard the bus.



Figure 4.9: York, Ontario, Canada Kerbside Station

In order to correctly create an effective station design we had to determine the frequency of passengers coming into the CBD. To determine the frequency of infrastructure entering the Cape Town CBD, the capacity of the buses and the number of passengers travelling into the City from the Culemborg Corridor was taken into consideration. The capacity of the current Cape Town bus is on average sixty-six passengers seated but in upgrading to articulated buses, the number of passengers per bus increases to roughly 120 passengers. From the current frequency found in the CPTR and an estimate of the modal shift, we predicted that there will be 2000 passengers travelling on the first phase of the BRT route.

From our survey, we found that around fifty percent of this estimate is heading into the East and West CBD as shown in Figure 4.7. From the CBD area, the largest intersection surveyed was Heerengracht and Coen Steytler. This intersection has the largest number of passengers exiting the bus which is five percent of the riders surveyed. Taking the largest number of passengers exiting the bus, we are able to see the amount of passengers the station needs to fit. The station capacity needs to at least hold five percent of the 1000 passengers estimated to exit in the CBD. The station recommended needs to assess the needs of at least fifty passengers.

Taking this size requirement into consideration we developed our recommended station design is shown in Figure 4.10 and 4.11. In the creation of this design we identified many important characteristics we wanted to include.



Figure 4.10: Front view of Station Design



Figure 4.11: Aerial Station View

Overall, we were looking for a simple design that had many modern elements. Our research disclosed that stations play a key role in the public image of the system. The City's goal in creating a modern station design is to encourage a new image of the system. A major aspect of this is found within our inclusion of a pillar that extends up through the center of roof in Figure 4.10. This is to be an illuminated beacon that will become a trademark of the system. The beacon will allow passengers to find stations easily late at night and will also add to the urban design appeal.

We also took into consideration the high crime rate in Cape Town when creating our design. To address this, every stop in the CBD will be equipped with an emergency call button, which will immediately notify security that an emergency has occurred at a station or in the vicinity. Architectural considerations will also aid in crime prevention. Plexiglas walls encourage visibility and prevent hidden spaces that can harbor criminals. We also tried to incorporate new technology into the station design as much as possible while keeping in mind maintenance and crime issues. A solution was the integration of the previously mentioned "smart pillar," which allows for riders to access information about the BRT route. This "smart pillar", found in the center of the station in Figure 4.11, we have named "FarePoint". The goal would be for a rider unfamiliar with the system, like a tourist, to easily access public transport, find timetables, and feel comfortable with the experience. In addition, this pillar will also meet multilingual demands of citizens especially during the transition to BRT or when changes in services occur. With fare collection occurring in the station, as opposed to on the buses, electronic card verification can be used on the buses to speed boarding times. The purpose of this pillar is to create a more accessible and efficient BRT system; ideally, this pillar will house an interactive kiosk, fare payment machine, emergency call button, and camera surveillance to discourage crime.

With comfort identified as one of the complaints in the current system, we wanted the stations to be user friendly for the passengers. Most important, was adequate seating. The seats were positioned so that they are protected from the weather. Loitering in stations and especially sleeping in stations after hours was found to be a concern as well. To remedy this problem benches in the station were outfitted with armrests. This addition adds to passenger comfort but makes sleeping on the benches very inconvenient. We also recommend the addition of both rubbish disposal facilities and newspaper stands in the vicinity of the stops.

In an effort to bring the spirit and culture of Cape Town into the stations we recommend choosing an area of the station to add the work of local artisans. With our station design the most feasible location would be the ceiling of the station. This will allow for an open canvas as well as a location that is not prone to graffiti. This aspect will also give each station a unique touch that makes it different and unique to the location while giving a sense of ownership to the citizens.

This overall design presents a modern image of the system while retaining aspects of the diverse past of the City. Though there are endless options for station design, this design fulfills each of the objectives we set out to achieve.

4.4 On-site Feasibility Analysis

An on-site feasibility analysis was used to test the viability of the routing design and was also used to determine possible station locations. We define an on-site feasibility analysis as an on-site test including pictures of streets, complimented by; observations, problem definitions and recommendations. Figure 4.12 is a route map with numbers at different streets and intersections, correlating with entries in the on-site feasibility analysis.

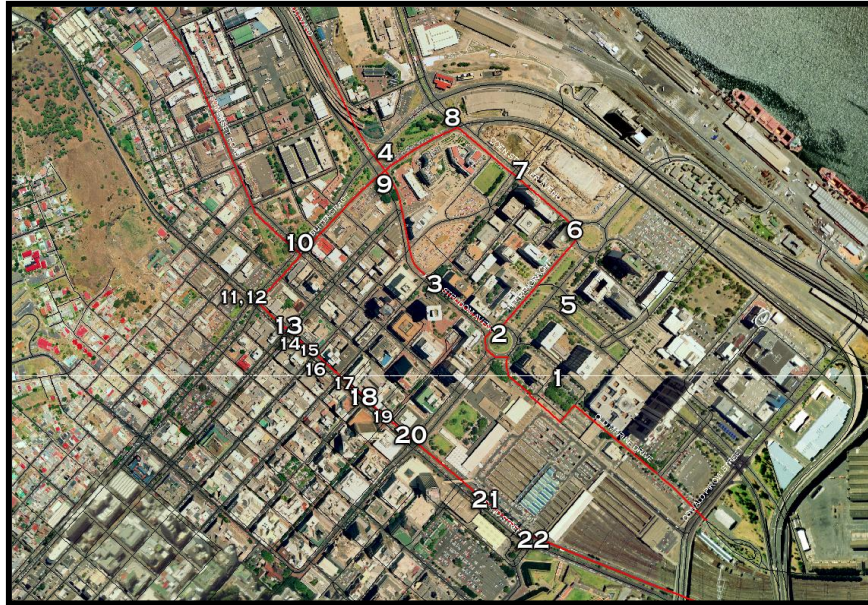


Figure 4.12: Locations included within the On-site Feasibility Analysis

The major recommendations from the on-site feasibility analysis include:

- Removal of on-street parking on all streets. To be replaced by either additional kerb space or BRT lane.
- Possible station locations include:
 1. Old Marine drive - Below Civic Center
 2. Heerengracht and Coen Steytler Intersection
 3. Buitengracht and Hans Stijdom
 4. Buitengracht and Riebeck
 5. Strand and St. Georges Mall
- Tree removal on kerb to accommodate stations.
- Begin discussions with business owners on these streets who may be impacted by BRT

Specific observations and recommendations can be found within the following document.

Prepared for the City of Cape Town Department of Transportation

December 6th, 2007



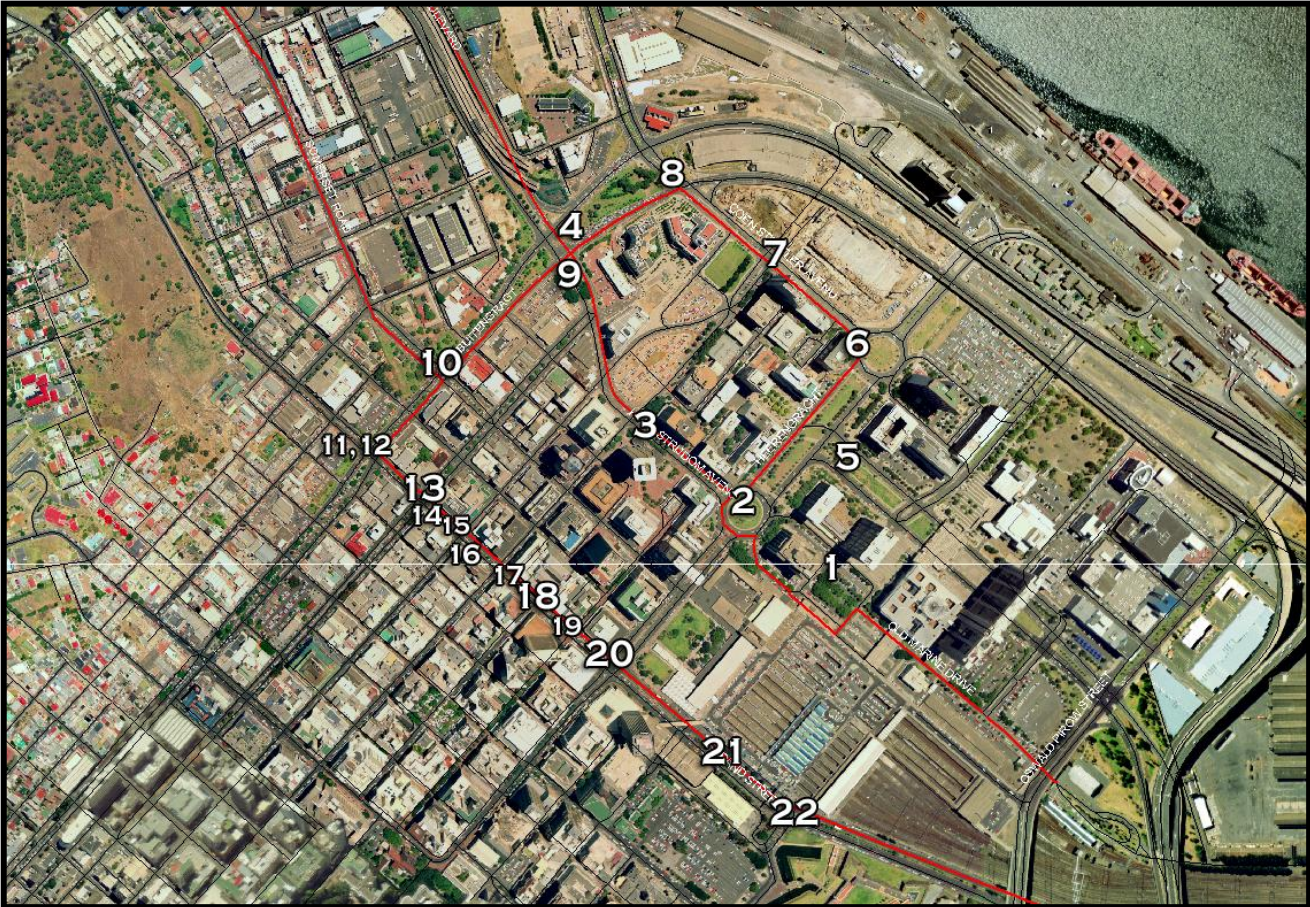
Compiled by:
Giselle Lewars
Omari McPherson
Nicholas Pelletier
Andrew Schwalbenberg





The on-site feasibility analysis found in this booklet is an assessment of the streets and intersections used along the proposed routing for the Cape Town central business district mapped in the figure on the left. Included are pictures of various locations along the route with comments that identify aspects of routing such as potential station locations, urban design concerns, planning issues, etc. The purpose of this model is to give a visual representation of the route along with its perceived challenges, with the intention of generating feedback discussion with stakeholders of this Inner City BRT Project.

Picture Locations within the CBD



The above figure pinpoints locations along the routing where observations were made and the pictures taken. Each location corresponds by number with the pictures throughout the feasibility analysis.

Proposed BRT Route – Sea Point Access



1. OLD MARINE DRIVE

Observations:

- Vehicle through movements limited
- High pedestrian activity
- High Parking
- Entrance into CBD from Culemborg Corridor

Recommendations:

- Proposed BRT Station below walkway to taxi rank
- Parking would need to be restructured to allow for bus movement and dedicated lane.
- There is room to eliminate parking on one side and install a dedicated lane or eliminate vehicle access to this street all together.



2. ADDERLEY/HANS STRIJDOM INTERSECTION

Observation:

- 4 way round-about
- Promotes vehicle movement

Problem:

- BRT will need priority

Recommendation:

- Intersection control to promote BRT movement. Eliminates need for dedicated lane.



3. HANS STRIJDOM AVE.

Observation:

- 3 Lanes each direction. On-street parking
- No accommodation for goods delivery

Problem:

- Trees would have to be moved/removed
- Friction impacts capacity, effectively operates as 2.5

Recommendations:

- Propose to widen sidewalk and remove parking
- Station proposed near corner of Long St based on ODS Create a dedicated lane.



4. Route continues straight onto Western Avenue out of CBD

Observations:

- Major intersection

Recommendations:

- Eliminate kerbside parking to allow for dedicated BRT lane
- Buses continue straight, prioritised signaling required.

Proposed BRT Route – CBD Loop



5. HERTZOG BOULEVARD

Observation:

- Large median
- Potential for 2 dedicated lanes

Recommendations:

- Median can be used for station
- Alternate route for Old Marine



6. HEERENGRACHT

Observation:

- Large median
- Potential for 2 dedicated lanes

Recommendations:

- Median can be used for station
- Alternate route for Old Marine



7. COEN STEYTLER (*facing Long St intersection*)

Observations:

- Narrow median

Recommendations:

- More suitable for community routes



8. COEN STEYTLER (*N2-Buitengracht intersection*)

Observations:

- Major intersection

Recommendations:

- Potential transfer link between line haul and community routes



9. BUITENGRACHT/ HANS STRIJDOM INTERSECTION

Observations:

- Suitable for both median and kerbside stop

Problem:

- Not pedestrian friendly

Recommendations:

- Signal Priority for BRT



10. RIEBEEK/ BUITENGRACHT INTERSECTION

Observations:

- 3 Lanes in each direction on Buitengracht
- Kerbside parking for businesses
-

Recommendations:

- Eliminate kerbside parking on Buitengracht
- Create dedicated lane on along kerb
- Prioritised signaling would be required for buses.



11. BUITENGRACHT/ STRAND INTERSECTION

Recommendations:

- Left turn only, no need for prioritised signaling
- Continue left turn concept for private vehicles from Riebeeck/Buitengracht intersection



12. STRAND STREET

Observations:

- Three lanes.
- Parking accommodation not consistent.
- Poor pedestrian access

Recommendations:

- Proposed to eliminate all parking along street and create kerbside dedicated lane



13. INTERSECTION WITH BREE ST

Recommendations:

- Eliminate kerbside parking to allow for dedicated BRT lane
- Use the resulting most left lane for left turns.
- Buses continue straight, prioritised signaling required.

14. STRAND STREET CONTINUED

Recommendations:

- Station proposed at 80 Strand Street (based on ODS and sidewalk space)
- Kerbside parking would be removed and replaced with dedicated BRT lane.



15.STRAND/LOOP INTERSECTION

Observations:

- 2.5 lanes and kerbside parking

Recommendations:

- Eliminate kerbside parking to allow for dedicated BRT lane
- Buses continue straight, prioritised signaling required.



16.STRAND STREET CONTINUED

Problem:

- Car rental business would need access to show room.
- Dedicated lane would run in front of business, if physical barrier is used accommodation would be required for business.



17.STRAND/LONG INTERSECTION

Observations:

- 2.5 lanes and kerbside parking

Recommendations:

- Eliminate kerbside parking to allow for dedicated BRT lane
- Buses continue straight, prioritised signaling not required.



18.STRAND STREET CONTINUED

Observations:

- Strand continues as 2.5 lanes with parking
- Various parking structures will complicate dedicated lanes.

Recommendations:

- Kerbside parking will be removed and dedicated lane placed kerbside
- If physical barriers are used accommodation would be required





19.STRAND/ST. GEORGE'S MALL INTERSECTION

Observation:

- Major pedestrian thoroughfare
- Road narrows to three lanes, no parking

Recommendations:

- Existing taxi rank on north side of intersection would be removed and replaced with a station.
- One lane to be used as dedicated BRT lane



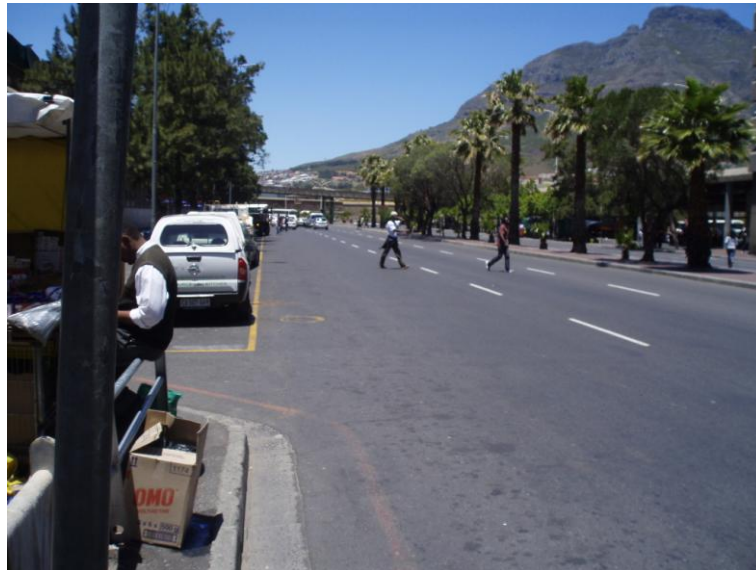
20. STRAND/ADDERLEY INTERSECTION

Observations:

- Four lanes and on street parking.

Recommendations:

- In-kerb parking will be removed and replaced sidewalk
- Left lane will be made into dedicated BRT lane
- Buses continue right, prioritised signaling required.



21. STRAND ST CONTINUED

Observations:

- Four lanes and on street parking.
- High loading/unloading zone

Conflicts:

- Loading/unloading will create friction for vehicles and/or BRT buses

Recommendations:

- In-kerb parking will be removed and replaced with loading/unloading zone
- Cargo vehicles cross dedicated lane and park next to kerb
- Left lane will be made into dedicated BRT lane
- Accommodation required if physical barriers are used for dedicated lane



22.STRAND STREET CONTINUED

Observations:

- Four lanes in both directions
- Existing bus stops
- Parking is on street

Recommendations:

- Left lane will be made into dedicated BRT lane
- Buses will use current stop location for stations
- Kerbside parking prior to these stops will be removed and dedicated lanes put in their place
- Buses continue down Strand and exit CBD.

23. DARLING STREET

Observations:

- 2 lanes in both directions
- Kerbside parking
- Portion of street has bus stops

Recommendations:

- Eliminate kerbside parking
- Use left lane and parking for dedicated BRT lane
- Signaling to be assessed in favor of BRT.

Photos Courtesy of Omari McPherson

5 Conclusion

Despite the ending of the apartheid, its long term effects still exist in the lives of the South African people. The non-whites who were forced into settlements far away from the City Centre during apartheid still remain deprived of many of the social and economic opportunities found in the City. The distance separating the underprivileged from the opportunities they seek is great, and the cost to travel to the City is not affordable for many. This detachment from access to the City's potential re-enforces the past and continues the overall feeling of segregation.

Cape Town strives to promote an image of unity despite its history. The City hopes to convince the attendees of the 2010 FIFA World Cup that the country is united. In order to accomplish its goal, the City has invested in re-developing its appearance. Many of the citizens of Cape Town are angered that money is being spent on renovations for the World Cup when there are still a multitude of citizens living within informal settlements in and around the City. There is a concern that decision makers and planners are not looking past the year 2010 and that the citizens of Cape Town will not benefit from this expenditure.

The government looks at the hosting of the World Cup as a chance to make a statement to the world. The updating of the City's infrastructure helps to create a new, modern image. A main part of this image is the City's public transportation. The current minibus taxi system is efficient and reliable but does not portray the modern image the City is hoping to achieve. Modifications to the City's public transport system will contribute to improvements necessary for the hosting of the World Cup as well as benefit the citizens of the City for years to come.

Our proposal contributes to this transportation overhaul while contributing to making social and economical opportunities more accessible. Bus rapid transit is a system that aims to decrease travel times, guarantee reliability, and offer low costs while maintaining the safety and security of the passengers. The lower cost appeals to the underprivileged by making the system more affordable. The lower travel times allows citizens living in settlements far away from the City Centre to decrease the time they spend traveling everyday. There are currently individuals who leave their homes hours before work to make a trip that would take just over thirty minutes with BRT.

This implementation of bus rapid transit along the Culemborg Corridor is truly going to set the pace for future improvements of public transit within the City. As seen in the case studies of other cities, and in the response of Cape Town's private mini-bus taxi associations, there will be resistance to the implementation of any new system. Developing an early relationship with these private companies by including them in areas of the decision-making processes will be a key to the progression of the project.

The success of this first route will be an example of the potential success of an entire system. For this reason, it is important that this first corridor serves as a cornerstone by exemplifying the true benefits of BRT. The implementation of a bus rapid transit system is a long term goal. It is an investment that will provide necessary routes for the high demand during the 2010 World Cup as well as provide daily transport for citizens of Cape Town. The implementation of bus rapid transit as outlined in our proposal will serve as an example of the potential social and economic benefits of BRT.

6 Works Cited

- BRISBANE, City of, 2006. *Transport Plan for Brisbane*. Accessed from: http://www.brisbane.qld.gov.au/BCC:BASE:1397551826:pc=PC_73 [Accessed 12 September 2007].
- Britannica Concise Encyclopedia , 2007. *Curitiba* [online]. Accessed from: <http://www.britannica.com/ebc/article-9028257> [Accessed 7 October 2007]
- BUCHWALD, F., 2007. Metrovía Guayaquil, operating a new public transport concept. *Public Transport International* [Electronic version]. May/June 2007, 72. Accessed from: http://www.uitp-pti.com/img/cover3_2007/17-en.pdf [Accessed 12 September 2007]
- The Bus Rapid Transit Policy Center, 2007. *BRT Policy Center: Metrovia*. Breakthrough Technologies Institute, February 2007. Accessed from: <http://www.gobrt.org/Metrovia.html> [Accessed 25 September 2007]
- CAIN, A., *et al.*, 2006. National Bus Rapid Transit Institute, Center for Urban Transportation Research, University of South Florida. *Applicability of Bogotá's TransMilenio BRT System to the United States* [online]. Accessed from: http://www.nbrti.org/media/documents/Bogotá%20Report_Final%20Report_May%202006.pdf [Accessed 9 September 2007]
- CAPE TOWN, City of, 2006. *Integrated Transport Plan for the City of Cape Town: 2006-2011* [online]. Accessed from: http://www.capetown.gov.za/policies/pdf/ITP_270706.pdf [Accessed 15 September 2007]
- CHAM, L., *et al.*, 2006. Federal Transit Administration, United States Department of Transportation. *Honolulu Bus Rapid Transit (BRT) Project Evaluation Final Report*. Accessed from: http://www.nbrti.org/media/evaluations/Honolulu_BRT_Final_Report.pdf [Accessed 18 September 2007]
- GOLUB, A., HOOK, W., 2003. The Institute for Transportation and Development Policy. *Sustainable Transport: São Paulo's Bus Reform Leads To Turmoil*.
- KOONCE, P. *et al.*, 2006. Evaluation of Comprehensive Transit Improvements – TriMet's Streamline Programme [online]. *Journal of Public Transportation*, 2006 BRT Special Edition. Accessed from: <http://www.nctr.usf.edu/jpt/pdf/JPT%209-3S%20Koonce.pdf> [Accessed 29 September 2007]
- LEVINSON, H.S., 2003. United States Federal Transit Administration, Transit Cooperative Research Programme, Transit Development Corporation, & National Research Council. *Bus Rapid Transit*. Washington, D.C.: National Academy Press.
- Metro Bus Inc., 2007. *Metro Bus Website* [online]. Accessed from: <http://www.ridemetrobus.com/fixroute/fares/> [Accessed 10 September, 2007]

Oregon, State of, 2007. *Population by City Name* [online]. Accessed from:
http://www.oregon.com/towns/population_alpha.cfm [Accessed 4 October 2007]

Tri-County Metropolitan Transportation District of Oregon, 2007. *The TriMet Story – History*.
Accessed from: http://www.trimet.org/about/history/trimet_story.htm [Accessed 3 October 2007]

VUCHIC, V.R., AND KIKUCHI, S., 1994. *The Bus Transit System: Its Underutilised Potential*
[online]. Washington D.C: U.S. Department of Transportation. Accessed from:
<http://ntl.bts.gov/lib/9000/9400/9410/56801.pdf> [Accessed 14 September 2007]

7 Appendix A: Supplementary Figures and Tables

	Bogotá	Guayaquil	Honolulu	São Paulo
Ridership	<ul style="list-style-type: none"> TransMilenio carries 1.3 million passengers per average weekday.(February 2007) 	<ul style="list-style-type: none"> The Guasmo-Río Daule corridor became operable in August 2006 and carries about 100,000 passenger trips/day (February 2007) 	<ul style="list-style-type: none"> Ridership increased 10-15% after the implementation of BRT About 63,000,000 passengers a year in 2005 Prior to the strike in 2002 which greatly decreased the ridership, the number was around 73,500,000 passengers. 	<ul style="list-style-type: none"> 8 million passengers daily 20 thousand passengers per hour Extreme decline in ridership and increase of car ownership leads to traffic congestion and pollution
Conflicts	<ul style="list-style-type: none"> Buses and stations are often overcrowded. Stations are not fully covered to protect from the weather Pick pocketing is a problem 	<ul style="list-style-type: none"> Customers complained about walking to stations because previously they were able to flag down buses. To resolve this issue, Metrovia stations are often closer than BRT stations in other cities. The law in Ecuador states that all passengers in a collective must be seated. This was due to unsafe conditions on these buses including abrupt stops. With dedicated lanes and designated stops, Metrovia permits standees. Pick pocketing is a problem 	<ul style="list-style-type: none"> In 2003 there was a strike that shut down the BRT system for an entire month September 2003 and greatly decreased the ridership. It has taken a while to gain back the trust of the ridership. TheFY2005 ridership is still 5.4% below that of the ridership found in FY2002. The public had a lot of resistance to the initial plans of dedicated lanes. 	<ul style="list-style-type: none"> Private companies unwillingness to cooperate with concession contracts by SP Tran Violent strikes made by the operators If Government tries to pay by passenger basis and private company react by cutting down on routes Tax payers affected by unprofitable routes charged based on kilometers Informal transportation competition Poorly integrated dedicated lane system on roads Poorly integrated bus system with metro and commuter rail
Privatization	<ul style="list-style-type: none"> Considering privatization (announced September 8, 2007) because of need for investment "The system is overseen by a public body, which awards contracts to private bus companies on a competitive basis. According to Transportation Research Board, Private contractors are paid based upon the total number of kilometers that their vehicles operate." 	<ul style="list-style-type: none"> Metrovia is a public-private partnership. The city provides the infrastructure and an outside corporation provides the finances. "Operations are provided by private contractors, typically former colectivo operators. The operators are paid directly from fare revenues and there are no operating subsidies. All funds go through a trust, not the city, thus providing Metrovia with some independence from political pressures and changes." 	<ul style="list-style-type: none"> Honolulu they did not choose to use privatization. Instead, the city created a non-profit organization that is an entity of the city known as Ohau Transit Services. 	<ul style="list-style-type: none"> Bus operations are privately owned Make decisions based on the benefits of company and not the country
Decentralisation	<ul style="list-style-type: none"> "TransMilenio is just one component of the city's overall Mobility strategy. Other transportation initiatives include a tag numbering system in which 40% of all cars must be off the streets during peak travel hours two days every week. This measure has reduced trip times by about 21 minutes and lowered pollution levels and gas consumption. Bogotá has also held a "Day Without Cars" once a year since 2000 with cars prohibited on city streets from 6:30 am to 7:30 pm." 	<ul style="list-style-type: none"> "Longer-term goals focus on planned development outside the city to decentralize city activities, and permanent closure of downtown streets to auto traffic with centre city transport provided by circulating buses or trams. The city has already celebrated its first Car-Free Sunday, temporarily closing streets to vehicles to give priority access to pedestrians and bicyclists." 	<ul style="list-style-type: none"> No reference to decentralized found 	<ul style="list-style-type: none"> Routes are affected since government want to pay on a per passenger basis Fares increase and passengers cannot afford to pay for long routes Loss of jobs due to lack of dependable and affordable transportation

Strategy	<ul style="list-style-type: none"> • Detailed Preparation of the System's Components. • Creation of the Managing Company • Facilitating the Involvement of Traditional Transport Companies • Contracting and Completion of the System's Infrastructure. • Contacting and Implementation of Operation and Collection Concessions, The Control Centre, and The Feeder Services. • Ensuring the Continuity of the Proposed Mass - Transportation Concept. • Communicating the New Transportation Concept, and Generating a Sense of Belonging. 	<ul style="list-style-type: none"> • Detailed Preparation of the System's Components. • Metrovía was built in phases, and will have seven trunk corridors when completed. By 2008, about 75 km of busway will be open, serving 490,000 daily passengers. 	<ul style="list-style-type: none"> • The overall system was implemented over a 5 year period with four separate routes. • Route A opened in 199, Route B opened in August 2000, Route C in May 2007, and Route E in 2004 • They took use of existing busing structures as much as possible and altered them as needed 	<ul style="list-style-type: none"> • Figure out how to obtain power from private companies • Re-design an efficient transit system
Fare Collections	<ul style="list-style-type: none"> • "The fare is 1,300 pesos, or roughly \$0.55, which enables passengers to travel anywhere in the system without paying any transfer fees. • As of February 2007, fare cards could be recharged through attendants at station entrances only, and only cash was accepted. However, there are plans to place fare machines outside of stations, thus reducing wait times to purchase or reload cards from attendants. There also are plans to put machines in convenience stores and other locations frequented by passengers, and TransMilenio is experimenting with using cell phones as smart cards. " 	<ul style="list-style-type: none"> • "The current fare is \$0.25 and, with discounts, the average fare is \$0.22. The control and fare collection system was designed for 600,000 trips per day, and the contractor complained that it is losing money until additional lines are built. The central government indicated, however, that fares could be raised to as high as \$0.30." 	<ul style="list-style-type: none"> • There are electronic registering fareboxes for collecting cash fares. • The fares are \$2.00 for adults and \$1.00 for children. More than 80% of passengers use a prepaid pass or a transfer validated by the driver. • The driver gives out transfer tickets so that an individual can get on another bus without paying again. • This high percentage of individuals using pre paid cards significantly speeds up the boarding process and the overall traveling times. The way they got so many people to get the pre paid cards is by offering significant discounts. For a month, it costs \$40.00 for adults and \$20.00 for children and \$5.00 for elderly and disabled. • Have picture of electronic fair box for proposal 	<ul style="list-style-type: none"> • \$1.05 USD per trip • Increase in fares drive passengers away to cars and traffic congestion begins • Fares paid to driver upon boarding
Station Stops	<ul style="list-style-type: none"> • The stations are like rail or subway stations, with multiple doors, level-boarding to vehicles, fare collection at the station entrance, electronic information signs showing arrival times for vehicles, glass door partitions between the stations and vehicles, and many other amenities. 	<ul style="list-style-type: none"> • Metrovía's two terminals are stunning pieces of architecture, large and airy structures that are reminiscent of European train stations. Located between the terminals are 34 glass, aluminum and steel stations, spaced about 400-500 meters apart. These stations are located much closer together than most South American BRTs since customers were not used to walking to stations (the colectivo buses stop only when flagged down). Automatic doors open when buses dock at station platforms. 	<ul style="list-style-type: none"> • All bus stations have raised kerbs for better access of the handicap. • Stations are very simple and include a bench and a covering as shown in picture. • Distance between stations is between ¼ of a mile to around a mile • In most cases this distance is almost twice as far as the typical local routes making the travel times much faster 	<ul style="list-style-type: none"> • Long bus routes because private company being paid by government kilometer not by passengers • 85% of passengers were able to make trip without stops but with the new 'intended' system they have to transfer at least twice to make it to destination

Route Planning	<ul style="list-style-type: none"> On major trunk lines, TransMilenio uses two dedicated lanes in each direction. This enables local service on the inside lane and express service on the outside lane, so that passengers can choose the route that is best for them. It also greatly reduces travel time for passengers, particularly when compared with most light or heavy rail systems, which have only one track in each direction, thus preventing trains from passing each other. 	<ul style="list-style-type: none"> Metrovia follows a north-south route roughly parallel to the waterfront. The route splits through the downtown for roughly 1 km, where each of the routes is one way. This helps the system to negotiate some fairly narrow streets and provides more extensive transit coverage in the downtown. 	<ul style="list-style-type: none"> There was much conflict concerning making dedicated lanes for the BRT. Many citizens were very upset and though the addition of dedicated lanes would further increase the congestion in Cape Town. In response they canceled the plans. In planning, they tried to create transportation hubs where both express (BRT) and local systems met and allowed individuals to transfer. The 4th route, Route E was closed in 2005 due to lack of ridership. This closer was at very little cost to the system because BRT allow you to very easily change drastically the transportation patterns without major infrastructure change. Route C caters mainly towards the rural population, bringing them to their jobs and the stores. 	<ul style="list-style-type: none"> Private companies do profitable routes Government pays company to run unprofitable route Informal minivans run routes for less money Informal minivans take most customers and buses cannot run with so few passengers because it does not make economic sense
Public participation	<ul style="list-style-type: none"> "Citizens in Bogotá are showing a positive change of attitude, reflecting in spontaneous compliance with civic rules, thus generating respectful behavior and friendly coexistence, cooperation, mutual support and civil commitment. In addition, a personal sense of belonging with regard to the System is particularly strong among children as privileged contemporaneous witnesses of its birth, and its ongoing growth process in the turn of the Millennium." 	<ul style="list-style-type: none"> According to a survey conducted by Guayaquil City Council in August 2006 • 70% of respondents rated the service as "good to excellent". • 80% of respondents rated driving as "normal to acceptable". • 94% of respondents indicated that there were no assaults or theft. • 95% of respondents are satisfied with the Metrovia system. 	<ul style="list-style-type: none"> The planning group held over 100 public meetings and gathered input from over 1,000 residents and commuters. Some of this outreach lead to the decision to discontinue pursuing dedicated lanes. Officials say the pressure by the public since the systems implementation has greatly diminished the ability to expand the system and make it more effective. 	<ul style="list-style-type: none"> Government asks for reduced fares for school children, disabled citizens and senior citizens Private companies do not profit from public participation Government has to pay private companies for public participation compensation

Table 4: Characteristics of Worldwide BRT Systems

City	BRT Status/ First Year in City	System Overview	Urbanize d Area Populatio n (millions)	Central Business District (CBD) Employment	Length (miles)	Cost Per Mile (Millions)	Number of Stations	Average Station Spacing (Feet)	Fare Collections	Vehicle Type	Rail Transit in City	Weekday Bus Riders	AM-Peak Hour, Peak Direction		Travel Time Savings (min/mile)	Travel Time Reduction (%)
													Buses	Riders		
Bogotá	2000	23-Mile, 4-Lane "TransMilenio" median bus-way with high platform centre island stations, where fares are paid, is served by articulated buses.	5.0	N/A	23.6	8	59	2110	Yes	Articulated		800,000		27,000		32
Brisbane	1990	South East busway BRT with attractive stations, offers both express and all-stop service. Buses use CBD bus tunnels.	1.5	60,000	10.5	19	10	5540	Ticket Machine	Standard	✓	60,000	150	9500	2	
Curitiba	1973	5 median busway system long 5 structural axis is carefully integrated with city development. Bi-articulated buses provide frequent rapid transit service to high platform stations, terminals.	1.6	N/A	37.2		139	1410	Yes	Bi-Articulated		340,000	40	11,000		
Honolulu	1999	Three City Express! And Country Express! Routes provide limited-stop service using distinctively coloured articulated buses.	0.9	N/A	26.6					Articulated		11,000			2.3	43
Los Angeles	1977	San Bernadino busway [Later HOV busway] opens.	9.6	200,000	12.2	6	30	21000	No	Standard	✓	9,600	40	1,800	2.6	38
	1979	Harbor and Santa Monica freeway HOV lanes have express bus service, stations.			11.8		3	7240			✓	18,000	70	2,750	1.5	28
	1999	Wilshire-Whittier and Ventura Boulevards. "Metro Rapid" limited-stop service uses distinctively coloured low floor CNG buses.			26		9	4580			✓	40,000	30	1,500	0.9	23
New York City	1963	Express buses use contra-flow bus lanes on 3 radial freeways; extensive bus lane network in Manhattan; limited-stop bus service on 25 routes in all 5 boroughs.	16.0	1,850,000	5	2	0		Swipe	Standard	✓		1130	46420	0.9	
São Paulo	1975	Extensive busway system includes Du-Jhulo and São Mateua Sabaquara. Median busways have staggered island platform stations with passing capabilities.	8.5	over 1.0 million	13		52	2000	Some	All	✓	426,000	220+	41600		

Adapted from Levinson, et al., 2003

8 Appendix B: Interviews

8.1 Interview with Lloyd Wright

Date: October 26th 2007

Location: Civic Centre

Conducted by: Nicholas Pelletier, Giselle Lewars, Omari McPherson, Andrew Schalbenberg

Name: Dr. Lloyd Wright

Representative of: Viva Cities

Sites familiar with: South American BRT

Sites experience with: South America BRT

Years experience working with BRT: Unknown

Information on BRT

- a. Lloyd mentioned when looking at BRT it is especially important to avoid transfers as much as possible. This is important due to the comfort of the passengers. This is currently done in Bogotá. Also, it is important to have access to the system within 500m for 90% of the CBD.
 - b. Fare system is also very important. Are we going to have open spaces or closed spaces.
 - c. He also mentioned it is difficult to use highways in BRT because you have to cross lanes to exit.
 - d. He mentioned that when looking at terminals it is true that they create much needed commercial space but it is important to point out that passengers lose a significant amount of time.
 - e. He presented us with a presentation prepared by Zida that dealt with route planning of the system in Cape Town.
-
1. Discussion of moving forward
 - a. Lloyd recommended mapping out important areas within the CBD.
 - b. Lloyd also recommended looking at the planning guide he has produced and also at what Johannesburg is currently doing.
 - c. We learned of a CBD planning meeting the following morning from 9:30-11:30am.
 - d. Lloyd also recommended it might be important to analyse both fare structure and community routes which is a necessary step in CBD planning.

8.2 Interview with Frederick De Villers

Date: November 11th 2007

Location: HHO Africa Offices

Conducted by: Nicholas Pelletier, Giselle Lewars, Omari McPherson, Andrew Schalbenberg

Name: Frederick De Villers

Representative of: HHO Africa

Sites familiar with: Culemborg Corridor

Sites experience with: Many architecture projects in the city of Cape Town

Years experience working with BRT: 2 years

Other Background: City planning including the V&A Waterfront

Information on the Culemborg Corridor

- f. Fred showed us the drawings his consulting firm has created for the proposed routing along the Culemborg Corridor.
- g. He explained prior choosing BRT the City had looked into other options including a Ferry that ran from Atlantis to the City of Cape Town. This idea was decided to be unsafe due to the rough seas present during the winter months. With other options having been considered, the City chose to move forward with BRT.
- h. He showed how their project works ends right as the corridor enters the CBD which is where our project commences.
- i. He pointed out some of the difficulties the team has encountered including the fact that there are many electrical lines and main drainage lines that run throughout the city that must be taken into consideration in the planning phase.
- j. He also explained how when planning there will be obstacles that will have to be overcome for example the route they are proposing goes right through a tile and granite store. He explained how the city first look into who owns the land and how long the lease is left on the building and then begin making offers until they are able to acquire the land. This is not included in his firms work.
- k. We were presented with mapping of the corridor they are proposing and he offered to provide us with cross sections if needed.

9 Appendix C: Station Design Manual

BRT Station Design



CITY OF CAPE TOWN | ISIXEKO SASEKAPA | STAD KAAPSTAD

THIS CITY WORKS FOR YOU

Prepared for the City of Cape Town Department of Transportation

November 1st, 2007

Compiled by:
Giselle Lewars
Omari McPherson
Nicholas Pelletier
Andrew Schwalbenberg





Table of Contents

1. Beijing, China.....	1
2. Bogotá, Columbia.....	2
3. Boston, MA, USA (Centralized).....	3
4. Boston, MA, USA (Side Station).....	4
5. Brisbane, Australia.....	5
6. Curitiba, Brazil.....	6
7. Edmonton, Canada.....	7
8. Honolulu, HI, USA.....	8
9. Las Vegas, Nevada, USA.....	9
10. Miami, FL, USA.....	10
11. Vancouver, Canada.....	11
12. Victoria, Australia.....	12

Beijing, China

Name: Beijing Residential Centre

Physical Description:

This stop in Beijing is located in the median of the roadway. Because of this fact, passengers are able to load buses in both directions from one central structure. The structure consist of a overhead roof as well as a booth from which to sell tickets and give information. To access this station an individual must travel in a tunnel underneath the street and come up under the station.



Services offered:

- Routes in two directions.
- Safe street crossing
- Overhead roof
- Information booth
- Security through closed station design

Advantages

- Provides for routes in two directions
- Overhead roof
- Central booth for fare collection and information
- Closed station for added security and safety

Disadvantages

- No wind protection
- Lacking amenities like bathroom facilities
- The design needs a significant amount of space
- Not the best design aesthetically

Bogotá, Columbia

Name: Bogotá median terminal

Physical Description:

Bogotá currently uses median stops that are closed access meaning that the fares are paid prior to entering the station. They are constructed from steel and have very limited seating. The doors open to the buses when they arrive. There are raised platforms to facilitate level boarding. They are a simple yet effective design. While a passengers comforts in the station may be compromised, there is often little time between buses.



Services offered:

- Passenger information kiosks
- Fare payment kiosks

Advantages

- Simple construction
- Closed station decreases dwell Time
- Easily accessible by bike and foot
- Design allows for quick boarding and alighting
- Safe pedestrian walkways and or overpasses increase safety
- Technology improves experience

Disadvantages

- Minimal passenger conveniences
- Typically no seating in station
- Bottleneck congestion during peak hours

Boston, Massachusetts

Name: Centralized Station

Physical Description:

This station was designed for high frequency interchanges. It is a large open air facility with 6 or more berths. It is a “smart station” in that it is disabled friendly as well as providing arrival times for passengers. To decrease travel times, fares are pre-paid. Boarding, though, does occur at grade unlike the platform stations.



Services offered:

- Passenger Information Kiosks
- Fare Payment Kiosks
- Newsstands/Vending Machines
- Restrooms

Advantages

- Modern design
- Security cameras
- Ticket vending machines
- Significant amount of real time digital signage
- Amenities for comfort of passengers

Disadvantages

- Enticing for vandals
- No wind protection

Boston, Massachusetts

Name: Street-side station

Physical Description:

For street side boarding and alighting this type of station has been proposed. This station is similar in architecture to the centralized terminal. They are open air and have a rear wind screen to protect passengers from the wind. There is also seating for six separate passengers at these locations.



Services offered

- Passenger information kiosks
- Fare payment kiosks

Advantages

- Simple construction
- Architecturally pleasing
- Visible to prevent vandalism
- Easily accessible by bike and foot
- Low cost/maintenance

Disadvantages

- Limited weather protection
- Not designed for all seasons
- Minimal passenger Conveniences

Brisbane, Australia

Name: Stones Corner Station

Physical Description:

The Eastern Busway in Brisbane is currently being constructed to meet the needs of residents along the eastern corridor to the city. The stations on this busway are individually designed with the help of local residents and businesses. Each has unique characteristics specific to the location. It has an elevated busway which is covered as an urban design feature. In the design process many near by roads were closed off to make a pedestrian plaza for improved comfort.



Services offered:

- Ticket vending machine
- Drink vending machine
- Conduits and pull boxes for land-line communications
- Customer information panel

Advantages

- Centralized Boarding/Alighting
- Car Parks for Commuting Riders
- Easy Access to Terminal
- Pre-Payment Reduces Dwell Times
- Riders Can Transfer Routes Easily

Disadvantages

The details of these stations are not yet available as they are currently underdevelopment however the urban design aspect is valuable.

Curitiba, Brazil

Name: Curitiba station

Physical Description:

These terminals are located at the end and in the middle of the route. They are closed in once fare has been paid at the beginning of the trip, interchange between local or urban buses require no further payments. The design is known as a tube stop and is equipped with doors to enter or exit buses which are coordinated with the doors of buses. They are raised platforms but do have disabled and wheel access to high level stops. The tube stops are very convenient and attractive to passengers and safe for weather protection.



Services offered:

- benches

Advantages

- Real time passenger information
- Smart card fare systems
- Integrated fare structure
- Weather Protection
- Stops serve three times the amount of passengers per hour compared to a conventional bus stop.

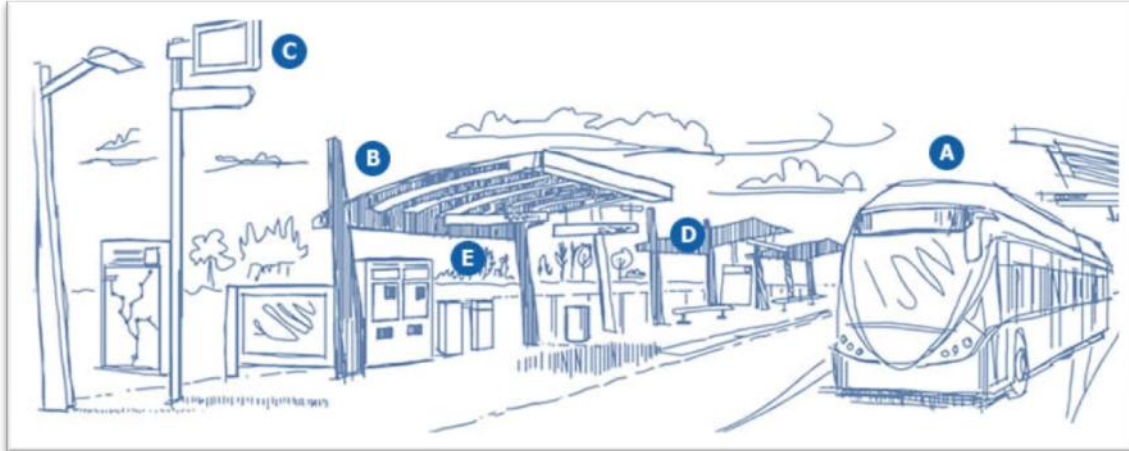
Disadvantages

- Size limitations during peak hours may cause congestion in tubes
- There is no on-vehicle fare collections
- No display of travel passes to bus drivers
- It is necessary that buses stop accurately at tube stops

Edmonton, Canada

Name: Edmonton City Centre

Physical Description:



1. **A** BRT vehicles: modern appearance, with features that include: low floors with wide, multiple doorways, for fast, easy boarding and exiting, powered by clean-burning or low-emission fuels, wheelchair accessible and bicycle friendly.
2. **B** Stations: located at major activity centres, stations will be designed with customer comfort, safety and security in mind. They will be larger than a standard bus stop, with upgraded waiting facilities and some, at strategic locations, developed with Park and Ride lots.
3. **C** Intelligent Transportation Systems: provide a broad range of digital technologies including: video surveillance capabilities, transit signal priority, queue jumping and Automatic Vehicle Locator system, all of which help keep schedules and service at peak performance.
4. **D** Ticket Vending Machines: On BRT you pay your fare at the station not on the bus. Stations along BRT routes will be equipped with advanced fare.
5. **E** Display Monitors: convenient electronic signage providing real-time next bus arrival information.

Advantages

- Centralized boarding/alighting
- Car parks for commuting riders
- Easy access to terminal
- Pre-payment reduces dwell times
- Riders can transfer routes easily

Disadvantages

- Has large footprint
- Too many options can be confusing
- Not much shelter
- No independent access for buses

Honolulu, Hawaii

Name: Honolulu CBD

Physical Description:

The stops in Honolulu are simplistic but take into account the general culture of the Island. By that, they fit in with the rest of the structures within the CBD. The structures consist of two benches covered by an overhead roof. The sides seem to be made out of wood indigenous to the island and the roof is made out of green metal for adequate protection.



Services offered:

- newspaper vending machines
- rubbish bin for trash disposal
- signage of route services

Advantages

- Simple design
- Proper signage for passengers is provided
- Amenities are provided for comfort
- The look of the structure fits in with the area it is in
- The structure is easily portable if it needs to be moved

Disadvantages

- The design does not protect against wind
- The design does not provide other amenities like bathroom facilities
- There is no security
- There is no fare collection facility

Las Vegas, Nevada

Name: MAX station

Physical Description:

This is an open air station and is approximately 220 feet long. Platform is 65ft by 10ft with 17inch kerbs to allow for level boarding. They have an aluminum panel canopy as well as indirect and ground panel lighting. MAX is the first in the United States to operate the Civis vehicle using the latest technology to provide a high-quality, state-of-the-art, environmentally-friendly transit alternative at a fraction of the cost of rail service.



Services offered:

- 24-hr Security
- Landscaping
- Smart Station Design
- Real-time electronic bus info
- Glass for safety and visibility

Advantages

- Architecturally Pleasing
- Handicap accessible
- Easily Accessible by Bike and Foot
- Low Cost/Maintenance

Disadvantages

- Limited Weather Protection
- Not Designed for all Seasons
- Annual operating and maintenance costs have not yet been determined.

Miami, Florida USA

Name: Miami Dade Bus Terminal

Physical Description:

This large scale terminal has a very modern design. The bays are constructed with great length to allow for multiple buses to queue along them. There is also easy access to nearby car and bike parking facilities. While waiting a passenger can seat themselves on a bench or make use one of the pay phones inside the station.



Services offered:

- Waiting area
- Pay telephones
- Benches
- Information services
- Park and ride lots
- Shops, police station, and administrative

Advantages

- Long stations permit a lot of space for buses
- Simple yet attractively designed
- Waiting areas are waterproof
- lights to illuminate waiting areas

Disadvantages

- No facility for transfers to and from feeder buses and busways

Vancouver, British Columbia, Canada

Name: Vancouver BRT

Physical Description:

Vancouver, British Columbia currently utilises a very practical and rider-friendly BRT station. The stops are kerbside or median and provide easy access for boarding and alighting. The stations are long open air glass and steel structures with wind screen on three sides. There are leaning rails as well as at grade crossing and boarding.



Services offered:

- Passenger information kiosks
- Public pay phones
- Newsstands
- Fare payment kiosk capability
- Technologically advanced
- Provide estimated arrival times
- Three to four bus berths

Advantages

- Pre-payment reduces dwell times
- Easy access for riders
- Some amenities are provided
- Technology increases comfort
- Arrival times reduce stress
- Independent bus arrival/departure

Disadvantages

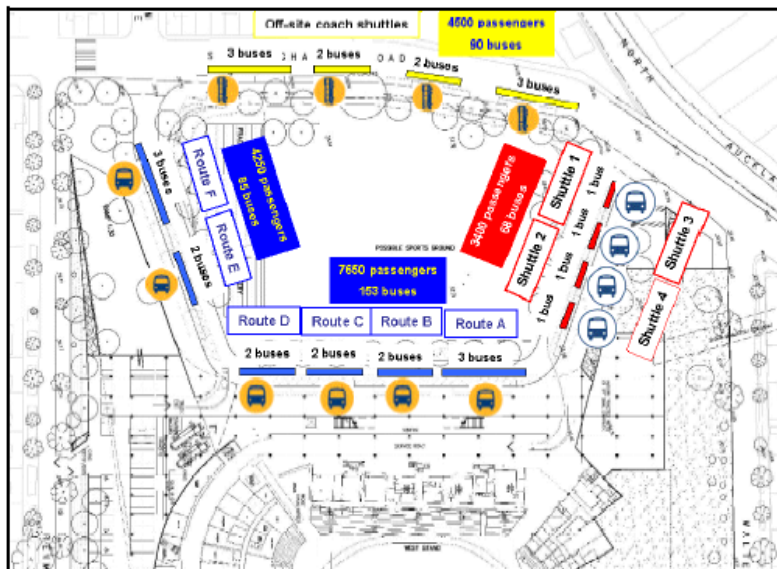
- Glass prone to breaking
- Limited seating
- Length can reduce wind shelter
- Technology and facility requires maintenance

Victoria, Australia

Name: Eden Park Terminal

Physical Description:

This station was designed as the focal point for the redeveloped stadium and contains large open space that can be used by the community during non-event periods. The stops in Honolulu are simplistic but take into account the general culture of the Island. By that, they fit in with the rest of the structures within the CBD. The structures consist of two benches covered by an overhead roof. The sides seem to be made out of wood indigenous to the island and the roof is made out of green metal for adequate protection.



Services offered:

- Bus stands and 'milling' areas
- Toilet facilities
- Shops
- Ticket machines
- Seats
- Service information

Advantages

- Passenger comfort – seating, toilets, and weather protection
- Quality environment and amenities
- Information systems – real time information, way finding signs, stand identification, platform maps and service information board (fares, schedules, etc.)
- Security measures – CCTV and police coverage

Disadvantages

- Shuttle buses are not permitted to park at the terminal but instead unload and load at a bus layover area.

York, Ontario, Canada

Name: York Region Transit – VIVA

Physical Description:

Vivastations are more than mere stops - they're beginnings. These are "smart" transit shelters equipped with a ticket vending machine, an electronic ticket validator, and a real-time vivasmart display that tells you exactly when to expect the next viva bus. The facilities consist of ticket vending machines as well as conventional shelters.



Services offered:

- Stand alone ticket vending machines
- Conventional shelters

Advantages

- Architecturally Pleasing
- Comfortable
- Easily Accessible by Bike and Foot
- Well-lit

Disadvantages

- Minimum passenger conveniences

10 Appendix D: ODS Survey

City of Cape Town Public Transport Origin/Destination Survey Atlantic Seaboard - CBD Link



CITY OF CAPE TOWN | ISIZEXO SASEKAPA | STAD KAAPSTAD

THIS CITY WORKS FOR YOU

The purpose of this survey is to collect public transit data from the Atlantic seaboard to the central business district in an endeavor to improve the public transportation in this corridor.

NOTE: This survey is completely anonymous; no personal information will be published at anytime.

Date: _____ Minibus Bus Route #: _____ Surveyor: _____

Time: _____ Weather: Fair Cloudy Rain Other: _____

M / F Child Young Adult Working Age Elderly

1. *Where do you live and when did you leave your home?*

Nearest Street Intersection: _____ Time: _____

2. *Where did you board the taxi/bus and what time?*

Interchange/Nearest Street Intersection: _____ Time: _____

3. *How did you get to the taxi/bus?*

Walk Bike Metered Taxi Privately Owned Vehicle Other: _____

If you took a car did you park at the interchange? Yes Dropped Off Other: _____

4. *Where do you get off the taxi/bus?*

Public Transport Destination/Nearest Intersection: _____

5. *What is your final destination?*

Nearest Street Intersection: _____

Work Residential Commercial Education Medical Leisure Other: _____

6. *How do you get to your final destination after getting off the taxi/bus?*

Walk Bike Minibus Metered Taxi Bus Other: _____

7. *What time do you arrive at your destination?*

Arrival Time: _____

8. *How often do you take this journey?*

More than Once a Day Daily ___ Times a Week Weekly Other: _____

9. *What is your main complaint about the public transport service?*

Punctuality/Time

Comfort

Safety on route

Safety at interchange or station

Other: _____

Entered: ____ / ____ / ____ Mapped: ____ / ____ / ____

11 Appendix E: Annotated Bibliography

BRISBANE, City of, 2006. *Transport Plan for Brisbane*. Accessed from: http://www.brisbane.qld.gov.au/BCC:BASE:1397551826;pc=PC_73 [Accessed 12 September 2007].

This report gave vast insight into Brisbane's proposed future and current transport systems.

Submitted by Omari McPherson

Britannica Concise Encyclopedia , 2007. *Curitiba* [online]. Accessed from: <http://www.britannica.com/ebc/article-9028257> [Accessed 7 October 2007]

This source has very good demographic information for Curitiba, Brazil.

Submitted by Omari McPherson

BUCHWALD, F., 2007. Metrovía Guayaquil, operating a new public transport concept. *Public Transport International* [Electronic version]. May/June 2007, 72. Accessed from: http://www.uitp-pti.com/img/cover3_2007/17-en.pdf [Accessed 12 September 2007]

This article is about how Guayaquil has achieved international recognition in the public transport sector with its new Metrovía system, an innovative management, regulation and operation control concept operated by the city council. Its self sustainability and contribution to social development and environmental protection were recognized this year when it won the Sustainable Transport Award in Washington DC. This document provides useful information on the strategies of a successfully implanted BRT system.

Submitted by Omari McPherson

The Bus Rapid Transit Policy Center, 2007. *BRT Policy Center: Metrovia*. Breakthrough Technologies Institute, February 2007. Accessed from: <http://www.gobrt.org/Metrovia.html> [Accessed 25 September 2007]

This source has a vast amount of information on BRT in general as well as specific to Guayaquil.

Submitted by Omari McPherson

CAIN, A., *et al.*, 2006. National Bus Rapid Transit Institute, Center for Urban Transportation Research, University of South Florida. *Applicability of Bogotá's*

TransMilenio BRT System to the United States [online]. Accessed from: http://www.nbrti.org/media/documents/Bogotá%20Report_Final%20Report_May%202006.pdf [Accessed 9 September 2007]

This report is full of information and graphics specific to the BRT on Bogotá, Columbia.

Submitted by Omari McPherson

CAPE TOWN, City of, 2006. *Integrated Transport Plan for the City of Cape Town: 2006-2011* [online]. Accessed from: http://www.capetown.gov.za/policies/pdf/ITP_270706.pdf [Accessed 15 September 2007]

This report is essentially the Cape Town plan for their improvements to mass transit over the next four years. It is a wealth of information.

Submitted by Omari McPherson

CAPE TOWN, City of, 2004. *Traffic Accident Report City of Cape Town 2004*. Available from: http://www.capetown.gov.za/reports/pdf/Traffic_Accident_Report_2004.pdf [Accessed 4 September 2007]

This is an extremely useful source full of accident statistics and general transit volumes in and out of the City of Cape Town. This source will be extremely useful for comparing the current accident statistics of similar cities with a BRT to see if they are improved. Also these numbers can be used as motivation to adopt the BRT system in order to reduce the annual crash rate.

Submitted by Andrew Schwalbenberg

CHAM, L., *et al.*, 2006. Federal Transit Administration, United States Department of Transportation. *Honolulu Bus Rapid Transit (BRT) Project Evaluation Final Report*. Accessed from: http://www.nbrti.org/media/evaluations/Honolulu_BRT_Final_Report.pdf [Accessed 18 September 2007]

The authors of this report completed a full evaluation of the bus rapid transit system of Honolulu. The report discusses some of the key components of the BRT system. The report also discusses how the system, which was just completed recently, has drastically changed the Honolulu transportation system.

Submitted by Nicholas Pelletier

CURRIE, G., 2006. Bus rapid transit in Australasia: Performance, lessons learned and futures. *JOURNAL OF PUBLIC TRANSPORTATION*, 9 (3).

This paper presents a review of Bus Rapid Transit systems in Australasia, including Brisbane. It outlines their infrastructure, operations and development characteristics. The performance of these systems in terms of patronage, markets, operations and overall urban development impacts is described. Lessons learned in their implementation and operation is also reviewed. The paper also includes a discussion of the major findings of this review.

Submitted by Omari McPherson

DEUTSCHER, K., AND PASIECZNY, J., 2003. Brisbane's New Bus Priority and Busway Initiatives - Government Agencies in Partnership. *In: Smart Urban Transport Conference, 27-29 May 2003 Sydney.*

Information garnered from a presentation by Ken Deutscher (Manager Transport and Traffic Branch, Brisbane City Council) and Jurgen Pasieczny (Queensland Transport, Brisbane Australia). These facts will prove useful in our case study of Brisbane.

Submitted by Omari McPherson

DEWAR, D., AND TODESCHINI, F., 2004. *Rethinking Urban Transport After Modernism: Lessons from South Africa.* Hants, England: Aldershot; Burlington, VT: Ashgate.

The authors, David Dewar and Fabio Todeschini, fully evaluate the current transportation system in Cape Town. Their writing discusses the flaws that the current system has and how these flaws negatively affect the CBD. The book also addresses aspects that need to be addressed in any future system and how the current system is simply not sustainable. This will provide useful information

Submitted by Omari McPherson

FEIGIN, S. *et al.*, 2003. United States Federal Transit Administration, Transit Cooperative Research Programme, Transit Development Corporation, AND National Research Council. *Travel Matters: Mitigating climate change with sustainable surface transportation.* Washington, D.C.: Transportation Research Board of the National Academies.

This report uses climate change and other pollution matters and evaluates the sustainability and effects of surface transportation including BRT and other bus systems. This report also looks into the changing view on sustainability in the world and how that applies to BRT and transit in general.

Submitted by Andrew Schwalbenberg

FREIBURG, L., 2001. Innovative Solutions for Public Transport; Curitiba, Brazil. *Sustainable Development International*, 3rd Edition, 153-156.

This source has a vast amount of information pertaining to the intricacies of the BRT system in Curitiba.

Submitted by Omari McPherson

GOLUB, A., HOOK, W., 2003. The Institute for Transportation and Development Policy. *Sustainable Transport: São Paulo's Bus Reform Leads To Turmoil*.

This publication includes a detailed account on the development and deterioration of the bus system in São Paulo. It describes San Paulo's experiments with bus ways, the perspective of private bus operators, the conflicts, and the negative effects on the economy.

Submitted by: Giselle Lewars

Greater Cleveland Regional Transit Authority, 2006. *Euclid Corridor: Silver line*. Available from: <http://www.euclidtransit.org/home.asp> [Accessed 8 September 2007]

This site details every aspect of a current bus rapid transit system being implemented in Cleveland. The site not only has multiple visual layouts of the infrastructure and route that is being implemented, but also the site has the contact information for multiple individuals connected with the project that would be great to interview. With a completion date of 2009, this project is a may be a great comparison for Cape Town.

Submitted by Nicholas Pelletier

GWILLIAM, K., 2002. The World Bank. *CITIES ON THE MOVE: A WORLD BANK URBAN TRANSPORT STRATEGY REVIEW* [online]. Washington D.C.. Accessed from: http://www.worldbank.org/transport/urbtrans/cities_on_the_move.pdf [Accessed 10 September 2007]

The World Bank presents a detailed yet comprehensive review of strategies toward Bus Rapid Transit. This includes a strategy for poverty-focused Urban Transport and infrastructure. A look at this review will prove very useful to the development of our proposed plan for Bus Rapid Transit.

Submitted by Omari McPherson

HIDALGO, D., CUSTODIO, P., AND GRAFTIEAUX, P., 2007. United Kingdom Department for International Development and the World Bank. *A Critical Look at Major Bus Improvements in Latin America and Asia: Case Studies of Hitches, Hiccups and Areas for Improvement' Synthesis of Lessons Learned*. United Kingdom.

This report studies the problems of bus operations faced in Latin America and Asia. It details the origins of these problems, how they may be avoided, and how they will be addressed. It gives recommendations and conclusions for transportation issues.

Submitted by: Giselle Lewars

HOOK, W. 2005. Institute for Transportation and Development Policy. *Institutional and Regulatory Options for Bus Rapid Transit in Developing Countries: Lessons from International Experience*. New York, New York.

This paper discusses how cities use bus rapid transits to create an efficient method of transportation for its users needs. It also discusses the importance of demanding more from private bus operators with the implementation of a BRT.

Submitted by: Giselle Lewars

HUME, T.W., CHAPMAN, P.H., FOO, P.S., 1989. Institution of Civil Engineers, Great Britain. *Singapore bus rapid transit: Planning and Implementation*. 86, 627.

These conference proceedings contain a report of how the bus rapid transport system in Singapore was constructed and implemented. It details what was needed and added to make the system and success.

Submitted by Nicholas Pelletier

KOONCE, P. *et al.*, 2006. Evaluation of Comprehensive Transit Improvements – TriMet’s Streamline Programme [online]. *Journal of Public Transportation*, 2006 BRT Special Edition. Accessed from: <http://www.nctr.usf.edu/jpt/pdf/JPT%209-3S%20Koonce.pdf> [Accessed 29 September 2007]

This journal article is full of vital information pertaining to the Portland, Oregon BRT. It is very comprehensive and gives great insight into the organization, planning and implementation of the system.

Submitted by Giselle Lewars

LEVINSON, H.S., 2003. United States Federal Transit Administration, Transit Cooperative Research Programme, Transit Development Corporation, & National Research Council. *Bus Rapid Transit*. Washington, D.C.: National Academy Press.

This report evaluates all aspects of the BRT system including things to look for to implement the system, effects of implementation and other factors that directly affect the outcome of the system. This also has several case studies and reports from several cities worldwide that are currently using or are in the planning stages of a BRT system.

Submitted by Andrew Schwalbenberg

MENCKHOFF, G., 2005. The World Bank Institute of Transportation Engineers. *Latin American Experience with Bus Rapid Transit*. Australia.

This report gives an overview of ten Latin America bus rapid transits including São Paulo, and eleven other transits that will begin its process of bus operations in the next two years.

Submitted by: Giselle Lewars

Metro Bus Inc., 2007. *Metro Bus Website* [online]. Accessed from: <http://www.ridemetrobus.com/fixedroute/fares/> [Accessed 10 September, 2007]

This site contains graphics for our project

Submitted by Omari McPherson

Municipal Urban Mass Transport Foundation of Guayaquil, 2007. *Espuema General* [online]. Accessed from: http://www.metrovia-gye.com/default1_archivos/esquem.htm [Accessed 7 September 2007]

General scheme of the Guayaquil Metro will be useful when looking at BRT routes that have been implemented elsewhere.

Submitted by Omari McPherson

Oregon, State of, 2007. *Population by City Name* [online]. Accessed from: http://www.oregon.com/towns/population_alpha.cfm [Accessed 4 October 2007]

This website is home to numerous facts about the State of Oregon.

Submitted by Giselle Lewars

PATANKAR, V.M., KUMAR, R., TIWARI, G., 2007. Impacts of bus rapid transit lanes on traffic and commuter mobility [Electronic version]. *Journal of Urban Planning And Development-ASCE*, 133 (2), 99-106.

The present study sets the groundwork for a methodology that can be used to selectively target corridor for BRT modeling in India. A dedicated lane-based public transport system shows the promising results and has to play a significant role in developing sustainable transport systems. These findings can be used to form the basis for developing better public transport corridors in present Cape Town.

Submitted by Omari McPherson

PETERS, J., 2007. Bus 2.0. *The Boston Globe* [online], 6 May. Available from: http://www.boston.com/news/education/higher/articles/2007/05/06/bus_20/ [Accessed 5 September 2007]

This article consists of creative solutions to public transportation problems around the world. This source will be useful when brainstorming alternative ideas and suggestions for dealing with the transit problem.

Submitted by Omari McPherson

PRIDDLE, R., 2002. International Energy Agency. *Bus Systems for the Future: Achieving Sustainable Transport Worldwide*. Paris, France

This report describes the international effort towards sustainable transport and goes into depth on BRT as a viable option. This report also explores several case studies and compares and contrasts BRT with other mass transit options.

Submitted by Andrew Schwalbenberg

SBS Transit LTD. *SBS transit*. Accessed from: <http://www.sbstransit.com.sg> [Accessed 28 August 2007]

This website is the main website of the bus company that runs the bus rapid transit system found in Singapore. The site contains maps of the routes and bus schedules. It also contains press releases of some of the latest updates in their system.

Submitted by Nicholas Pelletier

St. JACQUES, K., LEVINSON, H.S., 1997. National Research Council. Transportation Research Board, United States Federal Transit Administration, & Transit Development Corporation. *Operational analysis of bus lanes on arterials*. Washington, D.C.: National Academy Press.

This report studies the effects of buses in downtown city lanes and the feasibility of dedicated bus lanes on city arterials roads and other major highways. This resource will help determine if the Cape Town infrastructure is sufficient to have a BRT system.

Submitted by Andrew Schwalbenberg

Tri-County Metropolitan Transportation District of Oregon, 2007. *The TriMet Story – History*. Accessed from: http://www.trimet.org/about/history/trimet_story.htm [Accessed 3 October 2007]

This online website gives the history as well as several interesting facts about the BRT in Portland, Oregon.

Submitted by Giselle Lewars

TRIANANTIS, S.C., 2007. Performance evaluation of bus routes: A provider and passenger perspective [Electronic version]. *Transportation Research Part E-Logistics and Transportation Review*, 43 (4), 453-478.

This paper outline the provision of bus services along different routes that comprise a public transit network is assessed, taking into consideration the service providers, the users and the societal perspectives. The proposed approach enables the decision maker not only to optimally allocate resources across the transit network but to achieve targets for societal variables that represent the environment in which the bus services are provided.

Submitted by Omari McPherson

United States General Accounting Office, 2001. *Mass transit: Bus Rapid Transit shows Promise* [online]. Accessed from: <http://www.gao.gov/new.items/d01984.pdf> [Accessed 8 September 2007]

This resource compiles all the statistics on the most recent bus rapid transit implementations across the United States. There is great information on cost comparisons and on the overall benefits that have been seen with this system.

Submitted by Nicholas Pelletier

VUCHIC, V.R., 2007. *Urban Transit Systems and Technology*. New York: John Wiley & Sons.

This is a highly comprehensive resource on transit systems. Vuchic looks at definitions and characteristics of different transit modes including BRT.

Submitted by Nicholas Pelletier

VUCHIC, V.R., AND KIKUCHI, S., 1994. *The Bus Transit System: Its Underutilised Potential* [online]. Washington D.C: U.S. Department of Transportation. Accessed from: <http://ntl.bts.gov/lib/9000/9400/9410/56801.pdf> [Accessed 14 September 2007]

Urban transport expert Dr. Vukan Vuchic, evaluates bus transit systems across the US, analyses their operational modes and offers suggestion for improvement. This report provides a well thought out framework on how to conduct an evaluation and analysis on a bus system.

Submitted by Omari McPherson