INTEGRATED PUBLIC TRANSPORT NETWORK PLAN 2032

Network Plan

CITY OF CAPE TOWN
ISIXEKO SASEKAPA
STAD KAAPSTAD

TDA
CAPE TOWN
The City of Cape Town's Transport and Urban Development Authority

VERIFICATION PAGE

PROJECT NAME: **DEVELOPMENT OF A CITY WIDE INTEGRATED PUBLIC TRANSPORT NETWORK (IPTN) AND THE CONCEPT DESIGN AND OPERATIONAL PLAN FOR THE IRT COMPONENT OF THE LANSDOWNE WETTON CORRIDOR**				
PROJECT NUMBER: TO1.CPT.000199		**DATE:** May 2014	**REPORT STATUS:** Final Draft	
CARRIED OUT BY: Royal HaskoningDHV Team			**COMMISSIONAED BY:** City of Cape Town	
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SYNOPSIS: Final draft document of the development of the Integrated Public Transport Network (IPTN)				
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QUALITY VERIFICATION: This report has been prepared under the controls established by a quality management system that meets the requirements of ISO 9001:2000.				
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CONTENT

TABLES

FIGURES

LIST OF ABBREVIATIONS

AMPH	Morning Peak Hour
AMPP	Morning Peak Period
BRT	Bus Rapid Transit
CITP	Comprehensive Integrated Transport Plan
CoCT	City of Cape Town
CPTR	Current Public Transport Record
DaR	Dial a Ride
DFA	Development Facilitation Act
DoRA	Division of Revenue Act
DoT	National Government Department of Transport
DTPW	Department of Transport and Public Works (Western Cape)
EA	Enumeration area
EDS	Economic Development Strategy of the City of Cape Town
GABS	Golden Arrow Bus Services
GLA	Gross Leasable Area
HBE	Home Based Education
HBO	Home Based Other
HBW	Home Based Work
HTS	CoCT Household Travel Survey (2013)
IDP	Integrated Development Plan
IPTN	Integrated Public Transport Network
IRPTN	Integrated Rapid Public Transport Network
IRT	Integrated Rapid Transport
IRT	Integrated Rapid Transit
KPI	Key Performance Indicator
LWC	Lansdowne-Wetton Corridor
MAP	Million Annual Passengers
MCA	Multi Criteria Analysis
MEC	Member of the Executive Council of PGWC responsible for Transport and Public Works
MLTF	Municipal Land Transport Fund
MRE	Municipal Regulatory Entity
MSA	Municipal Systems Act (Act 32 of 2000)
MTEF	Medium Term Expenditure Framework
NATMAP	National Transport Master Plan: 2005 to 2050
NEMA	National Environmental Management Act
NHTS	National Household Travel Survey
NLTA	National Land Transport Act (Act 5 of 2009)
NLTTA	National Land Transport Transition Act (Act 22 of 2000)
NMT	Non-Motorised Transport
NSDP	National Spatial Development Perspective
NSSD	National Strategy for Sustainable Development
PGWC	Provincial Government of the Western Cape
PGWC	Provincial Government Western Cape

PLTF	Provincial Land Transport Framework
PRE	Provincial Regulatory Entity
PSDF	Provincial Spatial Development Framework
PTIG	Public Transport Infrastructure Grant
PTNOG	Public Transport Network Operations Grant
RNIS	Road Network Information System
RP	Revealed Preference
RSI	Road Side Interviews
SANRAL	South African Road Agency Limited
SDF	Spatial Development Framework for the City of Cape Town
SMART	Specific, Measurable, Attainable, Relevant, Time-bound (objectives)
SNP	Special Needs Passengers
SP	Stated Preference
TCT	Transport for Cape Town (Transport Authority)
TDM	Travel Demand Management
TZ	Transport Zone

1. Introduction

1.1 Background to the project

The National Land Transport Act (2009) requires all metropolitan municipalities, to prepare a Comprehensive Integrated Transport Plan (CITP). An Integrated Public Transport Network (IPTN), which forms part of the CITP, is defined in the NLTA as a system in a particular area that integrates public transport services between modes, with through-ticketing and other appropriate mechanisms to provide users of the system with optimal solutions to be able to travel from their origins to destinations in a seamless manner with integrated pedestrian access for all passengers.

The purpose of the IPTN project is to develop an ultimate integrated public transport network and operational plan for the entire Cape Town metropolitan area, with the aim to improve mobility and accessibility for all residents. The IPTN plan encompasses all modes of public transport, including rail and road based technologies, as well as proposals for improving non-motorised transport (bicycle and pedestrian) access and park-and-ride facilities at modal interchange locations.

The IPTN plan determines which modes are best suited to cater for the existing and future public transport demand, route descriptions and modal interchanges, station and stop locations, system operational parameters, infrastructure needs and estimates of total system costs.

The long term network plan recommended in this report will, once approved by Council, be developed into an operational plan with prioritised corridors for implementation according to available funding.

1.2 Contextual Framework

1.2.1 National Framework

National Transport Policy, the Public Transport Strategy (PTS) and Action Plan (2007) support the planning and implementation of quality public transport networks. These documents highlight that quality public transport will enable South Africans to access employment, education, and other essential activities and services.

The Public Transport Strategy has two key thrusts, namely Accelerated Modal Upgrading and Integrated Rapid Public Transport Networks. The former referred to initiatives to transform and upgrade existing bus, taxi and rail services in the short to medium term while the latter seeks to implement high quality networks of rail priority corridors and BRT corridors starting in the 6 metro cities of the country by 2010 and extending to the next 6 large cities by 2014. The IPTN Plan is a key mechanism towards achieving this quality public transport system and putting the Public Transport Strategy into action.

1.2.2 Provincial Framework

The Provincial Land Transport Framework (PLTF) states that by 2050, the Transport System in the Western Cape is envisaged to be defined by the following elements:

- Fully Integrated Rapid Public Transport Networks (IRPTN) in the higher-order urban regions of the Province
- Fully Integrated Public Transport Networks (IPTN) in the rural regions of the Province
- A Safe Public Transport System
- A Well Maintained Road Network
- A Sustainable, Efficient, High Speed, Long Distance Passenger Rail and Freight Transport Network
- An efficient International Airport that links the rest of the World to the choice gateway of the African Continent
- International-standard Ports and Logistics Systems
- A Transport System that is not fully dependent on fossil fuel
- A Transport System that is integrated with land use.

1.2.2.1 *Transport for Cape Town*

The City has recently established its transport authority to be the custodian of all transport matters within the City itself and to be the interface with surrounding municipalities and other transport related stakeholders, with single point responsibility for transportation within the Cape Town functional region. The transport authority, Transport for Cape Town (TCT), focuses on providing resources, skills, and finances for targeted and investment-oriented service delivery to the citizens and other partners of the City. TCT is constituted in terms of the National Land Transport Act (NLTA) and the TCT Constitutional Bylaw, No. 7208 of 2013, and mandated to fulfil a number of functions to allow it to plan and implement integrated, good quality transport in Cape Town, amongst others the IPTN.

1.3 Guiding framework for the IPTN from the CITP

The City's Comprehensive Integrated Transport Plan (CITP) provides the strategy and guiding framework in which the IPTN is to be developed. The CITP outlines the strategic approach to designing an integrated public transport network for Cape Town that responds to the mobility needs of the future City, while aiming to achieve the appropriate mix of modes which provide a sustainable balance of adequate capacity and low travel time for all the trip purposes of a vibrant city (CITP, 2013).

1.4 Scope of this Document

It must be emphasised that this report is limited to describing the process of developing various public transport network options and testing them against a proposed Pragmatic Transit Oriented Development land use scenario for the year 2032 based on growth projections from 2012 data. The recommended preferred transport network resulting from the multi criteria evaluation is presented in this report, without developing an operational plan or implementation plan for this network. Once the preferred network has been approved or amended by the City, a detailed operational plan, a business plan and a prioritised phased implementation plan will be prepared.

The product of this IPTN Plan is a plan and a route directory showing and describing the proposed public transport network for the metropolitan area of the City of Cape Town and linkages to the affected surrounding municipal areas. The public transport network has been designed on certain assumption about the expansion of the infrastructure on which the network operates, and while the routes making up the network operate in assumed conditions e.g. on a dedicated right of way or in mixed traffic etc, the IPTN Plan submitted in this report does not provide definitive guidance on the long term public right of way plan, rail network, reservation of rail or road reserves or specifications pertaining to particular infrastructure unless specifically stated. The emphasis is primarily on the network of rail and trunk routes required to serve the future City.

For evaluation purposes, preliminary revenue and operational cost projections were determined but these will require revision in greater detail through the IPTN business planning and operational planning process. The development of the operation and business plan documents will be iterative and may result in refinement of the IPTN Plan as more detailed information becomes available.

This IPTN Plan will form the technical basis on which the following will be developed:

- IPTN Operational Plan which in detail will assess and describe level of service along the identified routes. This plan will address parameters like route optimization, appropriate fleet type, fare design and levels, frequency, headway, timetables, minimization of dead mileage, assess proposed depot and staging locations and other operational parameters of the network;
- IPTN Implementation Plan which will provide a roll-out plan detailing the phased implementation of the IPTN towards 2032; and
- IPTN Business Plan which will in detail report on both the economic and financial assessment of this preferred IPTN. The IPTN Business Plan will include a review of the Business Structure, Operating Contract Parameters and Industry Transition aspects.

The geographical extent of the land use and transport planning for the IPTN included the Cape Town metropolitan area as well as the surrounding towns of Malmesbury, Paarl, Stellenbosch and Wellington which fall within the functional area.

1.5 Methodology and Approach

The approach and methodology to the development of the Integrated Public Transport Network Plan is illustrated in the process diagram in the figure below.

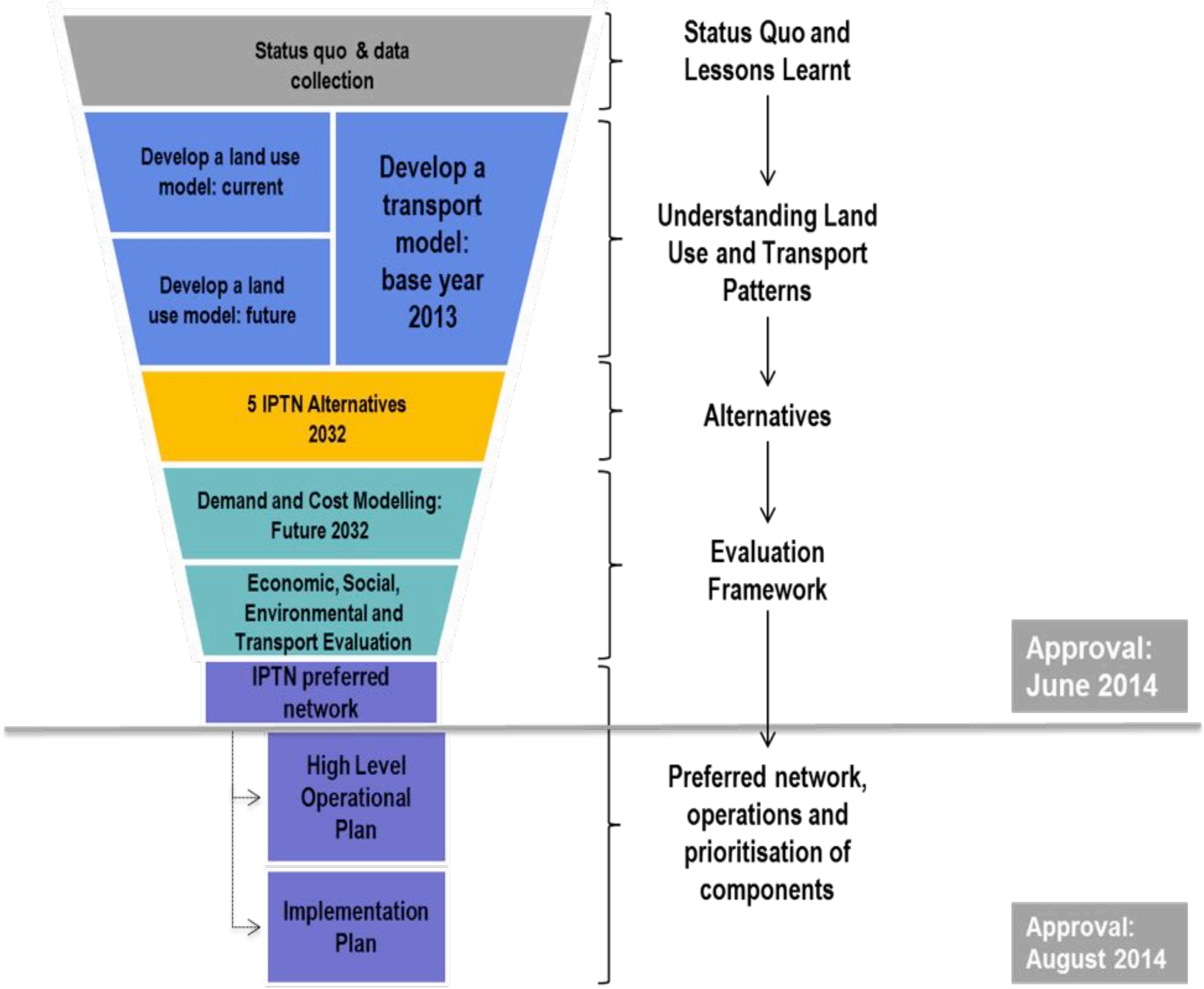


Figure 1-1: Process overview of the Integrated Public Transport Network Plan

The project commenced with obtaining and reviewing all significant planning documents concerning transportation and land use strategies in the metropolitan area during the past 15 years. Data from various transport surveys and the 2011 census was examined to determine trends in mode use, travel needs and shortcomings of the current public transport system. The results of household interviews with a sample of 22 000 families, conducted between January and June 2013 were also analysed with regard to number and time of trips made by household members and mode choice in relation to trip purpose, travel distance, household income and car ownership.

A transport demand model was then developed to predict travel on the roads (number of vehicles in the peak hour) and usage of public transport modes (passengers using trains, taxis, buses and non-motorised transport) based on population and employment distribution, land use and trip data obtained from the census, household surveys and other surveys. The model was then calibrated against observed vehicle and passenger counts so that it represented reality as closely as possible in its predictions for the base year (2013).

After calibration and validation, the model was used to predict future travel demand on various alternative transport networks for a proposed future land use scenario, using a 20 year planning horizon for projections of population and employment distribution. Various combinations of public transport routes and vehicle technologies (rail, BRT, conventional buses and minibus taxis) were tested in the model.

Three future land use scenarios were initially proposed to be tested during the transport demand modelling process. These scenarios are described in chapter 4 of this report and were called the following; Business as Usual (BAU), Pragmatic Densification (PD), and Pragmatic Transport Orientated Development (PTOD).

After initial proposals by the project team to test the IPTN alternatives with the PD land use scenario until a preferred alternative was selected, which would then be evaluated against the BAU and PTOD scenarios to test its sensitivity, it was decided to instead use the PTOD scenario for testing the alternatives. Once the preferred network has been selected for this scenario, the sensitivity of the preferred alternative will be evaluated against the BAU scenario, as well as against a more comprehensive TOD scenario. Therefore, the land use scenarios that will be referred to primarily in this IPTN Plan have been, or will be:

- "Business as Usual" (BAU) – to test the effect on the network if land use develops differently to PTOD
- "Pragmatic Transit Oriented Development " (PTOD) – used to design the IPTN on
- "Transit Oriented Development – Comprehensive" (TODC) – to test the effect on the network if land use develops differently to PTOD

Using the outputs from the 2032 IPTN modelling, the various networks were assessed and compared in terms of strategic economic, environmental, social, transport and financial implications, as well as regards alignment with the City's corporate plans and strategies. This comparative assessment was done using multi criteria analysis in order to arrive at a network which performed best and was affordable in terms of projected available funding for public transport.

2. Summary of status quo evaluation

2.1 Introduction

The IPTN project commenced in October 2012 with a review and evaluation of all previous transport planning done for the City, as well as a review of the policies and strategies of national and provincial government which have an influence on public transport planning and operations. The results of that review are contained in an IPTN document titled "Status Quo Review and Evaluation Report, Final Draft – September 2013". The salient findings and conclusions contained in that report, with regard to their influence in the development of the IPTN, are summarised in this chapter.

2.2 Data Collection

In order to develop, test and select a preferred IPTN, a significant amount of accurate data was required, including demographic and socio-economic characteristics, roads and public transport infrastructure, traffic flows and passenger travel demand patterns, land-use planning and development trends. The quality of all available data at the inception of the project was evaluated critically with regard to its adequacy and reliability for use in the development of the land use model and travel demand forecasting model.

A Data Gap Analysis report was prepared which listed all available data and identified whether it was suitable for use in preparing the IPTN and what gaps there were in the data, requiring further surveys to collect this data. A Data Collection Plan was then prepared to collect the required data, with time frames and estimated costs.

The data required to update the City's travel demand was collected by means of household interview surveys conducted with a sample of approximately 22 000 households throughout the metropolitan area. The surveys were conducted by a team of trained interviewers who visited the selected households on weekday evenings between 16:30 and 20:00 and completed a questionnaire which contained all the required information. For quality assurance purposes, interviewers handed their completed questionnaires to their supervisors after each five interviews for checking, before they undertook the next five interviews. If there were any errors or omissions, the interviewer was required to revisit the household to complete the questionnaire. The supervisor checked the quality of the data collection of the fieldworkers by repeating selected questions on a randomly selected household in every second enumerator area.

2.3 Current Public Transport System

Public transport in the City of Cape Town is provided by a network of services consisting of the following:

- Rail passenger services (Metrorail)
- Conventional bus services (GABS and Sibanye)
- MyCiti services (trunks and feeders)
- Minibus taxi services
- Metered taxi services
- Dial a ride service (City of Cape Town)
- Long distance services (road and rail)

The first four of the above services is explained in more detail in this chapter, in terms of routes, infrastructure, fleet, operations, fares and system performance. A summary of the modal share of passengers using the main modes of walking, private car and public transport (train, bus and minibus taxi) is provided in the table below, based on the results of the household interview surveys conducted during 2013. If a person uses more than one mode of public transport, the main mode is defined as the mode used according to the following hierarchical order of modes: train, bus, minibus taxi. Walk includes children walking to school. This modal split is for trips undertaken in the morning peak period (06:00 – 09:00).

Table 2-1: Peak Period Modal Split by Income Group (Household Survey 2013)

Main Mode	Low Income (% population)	High Income (% population)	All Persons (% population)
Walk	33%	4%	21%
Private Car	15%	82%	37%
Train	15%	4%	11%
Bus	9%	2%	8%
Minibus Taxi	20%	2%	15%
Other (bicycles, trucks)	8%	6%	8%

The total percentage of the public transport modal share is 34% which when compared with the private car mode of 37% gives a split, excluding walk and other modes, of 52:48 in favour of private transport.

2.4 Rail System

The existing PRASA passenger rail network serving the Cape Town region consists of nine routes radiating outwards from the Cape Town station. The network consists of 610 km of rail track with 1 473 signals and has 118 stations, as shown on the Metrorail route map below. The lines to Malmesbury and Worcester have only a few train services per day. These lines and the Monte Vista line are owned by Transnet Freight Rail (TFR).

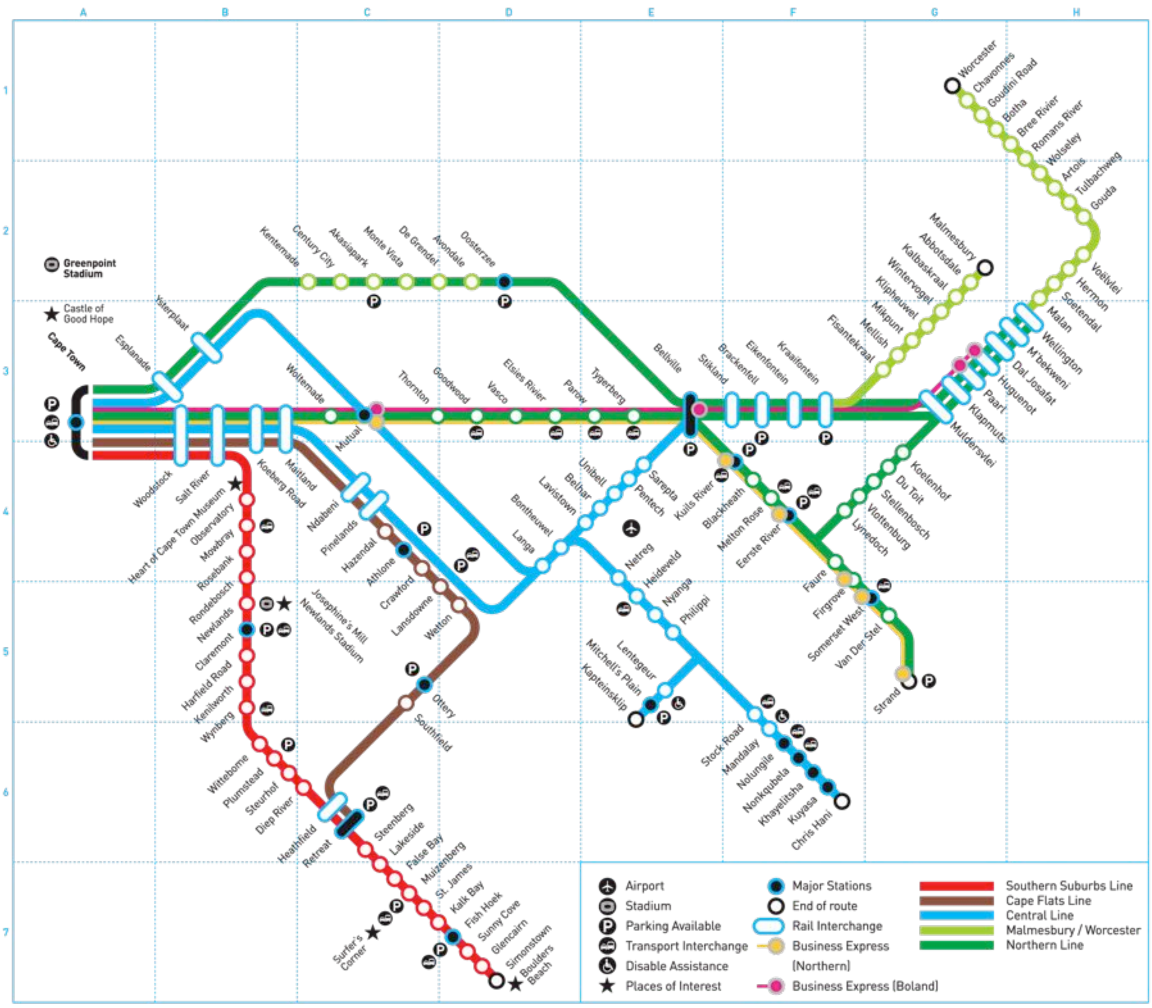


Figure 2-1: Western Cape Metrorail Route Map (Source: Metrorail website 2013)

Depot facilities for the maintenance and repair of rolling stock are located at Salt River and Paarden Eiland. Staging facilities for parking trains overnight are located at the following stations and yards (source: Metrorail, 2013):

- Cape Town Station
- Salt River Yard
- Paarden Eiland Yard
- Bellville Station
- Kraaifontein Yard

- Wellington Station
- Worcester Station
- Malmesbury Station
- Strand Yard
- Retreat Yard
- Fish Hoek Station

The control centre from which all train operations are controlled is currently located at Windermere in Century City, but will be relocated in future to Bellville, according to recent information obtained from Metrorail.

Facilities have been provided for modal transfer of passengers at several stations. These facilities include park and ride for private vehicle owners and bus and taxi embayments and/or ranks for public transport vehicles.

2.4.1 Fleet

The number of passenger train sets available to operate services in Cape Town has reduced from 94 in 2000 to 86 in 2012 as a result of increasing age of the rolling stock and inability to repair coaches. The average age of the fleet was 36 years in 2012. The reduction in fleet has also resulted in some trains now operating with fewer coaches than normal, so that the capacity of these train sets is lower than previously. The PRASA annual report 2011/2012 indicates that there were 899 operational coaches in Cape Town in 2010. PRASA has recently awarded a tender for the supply of new rolling stock throughout the country. Delivery of the first of the new coaches is expected to start in 2015/2016 and they are expected to be rolled out at a rate of 30 coaches per month, according to a statement made in the media by the PRASA CEO in May 2014. At this stage it is not known which cities will get priority in receiving new coaches.

2.4.2 Punctuality

The punctuality of train services is also affected by the condition of the rolling stock being susceptible to breakdown, as well as due to acts of sabotage such as cable theft. The PRASA annual report indicates that the percentage of train adherence to the timetable varied between 80% and 90% during 2010.

2.4.3 Headways

The automated train control system which controls about 80% of the signals is able to allow a 3 minute headway in theory, but the condition of the equipment and rolling stock does not allow this to be achieved in practise. For safety reasons, headways on the busiest lines during the peak periods are currently limited to 6 minutes which is equivalent to a frequency of 10 trains per hour. The frequency of service provided varies according to the actual passenger demand on each line.

2.4.4 *Business Express*

Metrorail operates an express service on two lines, from Paarl to CBD and from Strand to CBD, with fewer stops in order to reduce travel time. These services which operate one way in the peak periods are aimed at attracting choice users who are prepared to pay more for a superior service. The fare for the business express is about 5 times the Metro fare.

2.4.4.1 *Long Distance Train Services*

Shosholoza Meyl is the mainline division of PRASA and operates long distance regional and inter-city rail services. Two other long distance passenger train services are also operated, although not by PRASA. Both are aimed primarily at international tourists, namely:

- The Blue Train, from Cape Town to Pretoria
- Rovos Rail, from Cape Town to Dar es Salaam via Pretoria.

The Cape Town to Johannesburg Shosholoza Meyl service is one of the most utilised inter-city rail services in South Africa. Monthly volumes vary between 40 000 and 60 000, or approximately between 1300 and 2000 passengers per day.

2.4.4.2 *Fare Structure*

Metrorail fares are distance based with 10 km zonal trip distances up to 40 km and then two categories for longer trips (41 – 135 km) and (136 – 200 km). Discounts are offered for purchasing weekly and monthly tickets. Children under 12 and pensioners over 65 get 50% concessions on the normal adult fares, which are shown in Table **2-2** below.

Table 2-2: Metrorail Fares effective from 1 June 2013 (source: Metrorail website)

Km Zone	**Single**		**Week**		**Month**	
	Metro Plus	**Metro**	**Metro Plus**	**Metro**	**Metro Plus**	**Metro**
1 – 10	R8,00	R6,00	R64,00	R39,00	R192,00	R117,00
11 – 19	R9,00	R6,50	R72,00	R42,00	R216,00	R126,00
20 – 30	R11,00	R7,50	R88,00	R49,00	R264,00	R147,00
31 – 40	R14,00	R8,50	R112,00	R55,00	R336,00	R165,00
41 – 135	R17,00	R11,00	R136,00	R72,00	R408,00	R216,00
136 – 200	R21,00	R16,00	R168,00	R104,00	R504,00	R312,00

The average annual rate of increase has been 6% per year since 2010, with 8% increases for the shorter trips and 4% increases for the longer trips.

2.4.4.3 *System Performance*

The latest rail passenger survey is the 2012 Rail Census which showed that approximately 622 000 passenger trips are made over the entire Cape Town metropolitan network on an average weekday. This represents a decrease of roughly 2% from the 2007 Rail Census.

Ticket sales show that approximately 81% of the passengers use Metro class and 19% used Metro Plus class. Table **2-3** summarises the daily and morning peak period boarding passengers across the entire network.

Table 2-3: Railway passenger boarding per line for the whole day and the morning peak period (Source: Rail Census 2012)

SERVICE LINE		PASSENGERS BOARDING BOTH DIRECTIONS				
		ALL DAY			MORNING PEAK (06:00 to 09:00)	
		Metro Plus	Metro	Total	Total	% of daily
1	Simonstown to Cape Town	33 581	63 189	96 770	35 773	37.0%
2	Retreat to Cape Town via Maitland	15 271	30 658	45 929	18 057	39.3%
4	Wellington to Cape Town via Woodstock	18 871	72 509	91 380	30 022	32.9%
5	Muldersvlei to Cape Town via Esplanade and Stellenbosch	3 299	8 761	12 060	4 245	35.2%
7	Muldersvlei to Cape Town via Stellenbosch	4 626	13 416	18 042	6 809	37.7%
9	Strand to Cape Town via Bellville and Woodstock	10 220	34 082	44 302	15 553	35.1%
10	Bellville to Cape Town via Esplanade and Langa	1 859	33 184	35 043	9 961	28.4%
11	Bellville to Cape Town via Esplanade and Langa*	0	959	959	904	94.3%
13	Kapteinsklip to Cape Town via Woodstock and Pinelands	6 233	66 248	72 481	28 472	39.3%
14	Kapteinsklip to Cape Town via Esplanade and Mutual	388	5 852	6 240	3 380	54.2%
15	Chris Hani to Cape Town via Esplanade and Mutual	13 211	120 554	133 765	38 864	29.1%
17	Chris Hani to Cape Town via	1 498	17 040	18 538	3 883	20.9%

	Pinelands					
19	Wellington to Cape Town via Monte Vista	1 367	3 603	4 970	3 736	75.2%
21	Wellington to Cape Town via Woodstock	7 618	31 098	38 716	15 303	39.5%
23	Strand to Cape Town via Monte Vista	1 025	1 613	2 638	1 606	60.9%
TOTAL		**119 067**	**502 766**	**621 833**	**216 568**	**34.8%**

Table **2-4** shows previous rail census totals, which indicates an 8% reduction in daily train patronage from 2000 to 2012. Although the total daily boarding passengers in 2012 are about 2% less than in 2007, the latest survey indicates that it is roughly equal to the daily volume surveyed in 2004.

Table 2-4: Comparison between yearly rail census volumes and available trains sets (Source: GIBB, 2012)

Year	All day passengers boarding	Train sets		
		Running	**Spare**	**Total**
2000	675 607	90	4	94
2004	621 285	85	5	90
2007	635 046	81	6	87
2012	621 833	81	5	86

2.4.4.4 *Current PRASA Projects*

PRASA published its Western Cape Regional Strategic Plan in September 2012, which relates closely to the TCT strategic interventions intended for improving services and capacity in the City. This strategic plan has identified the following overarching high priority interventions for the Cape Town area that need to be addressed in the short to medium term:

- Replacement of rolling stock with new, modern, and higher capacity vehicles;
- A revision of the ticketing strategy that will encourage users to travel during less busy times. This strategy will entail a migration to an electronic ticketing system;
- Corridor prioritisation - various corridors in the City have been prioritised for upgrading based on the expected growth in demand;
- A new line from Nolungile Station to Kuilsriver Station through the Blue Downs area;

- Infrastructure upgrades:
  - o Signalling upgrades to provide improved headways (to 3 minutes between trains), higher running speeds, Automatic Train Protection and higher reliability,
  - o Increasing the number of available platforms and running lines;
- Development of principle stations have been identified to receive enhancements to improve the convenience in using the station and its facilities;
- Increasing the fleet size from 81 to 141 train sets in the long term.

2.5 Minibus Taxi System

Approximately 565 routes are operated by minibus taxis in the Metro. See Figure **2-2** for a layout of the **Minibus Taxi Routes.** Routes generally link the taxi ranks and public transport interchanges in the residential areas with the places of employment in the economically active areas of the City. Although minibus taxi operators are licensed by the Provincial Regulatory Entity (PRE) to operate on specific routes, a set of surveys conducted in the MyCiTi Phase 1A area indicated that it was possible that approximately half the operators are either not licensed or operate on unauthorised routes..

2.5.1.1 Service type

The minibus taxi service operated on-demand and is an unscheduled and unsubsidised service which provides a direct service between ranks along a particular route or routes. Feeder/distribution services are provided in residential areas as per demand.

Most route based services run along major arterials and highways. The route based services are normally operated by licensed operators. Area based services are generally found within the residential areas providing a feeder/distribution service to the route based services. These area based services appear to be operated by the unlicensed operators.

2.5.1.2 Holding and staging

Holding and staging areas are incorporated in the design of most of the Minibus Taxi interchanges and ranks. Staging areas at interchanges are usually separated into destination/route queues with each destination having its own queue. Holding areas are normally positioned adjacent to or near to the interchanges. At some of the interchanges the holding areas include a wash bay for the vehicles.

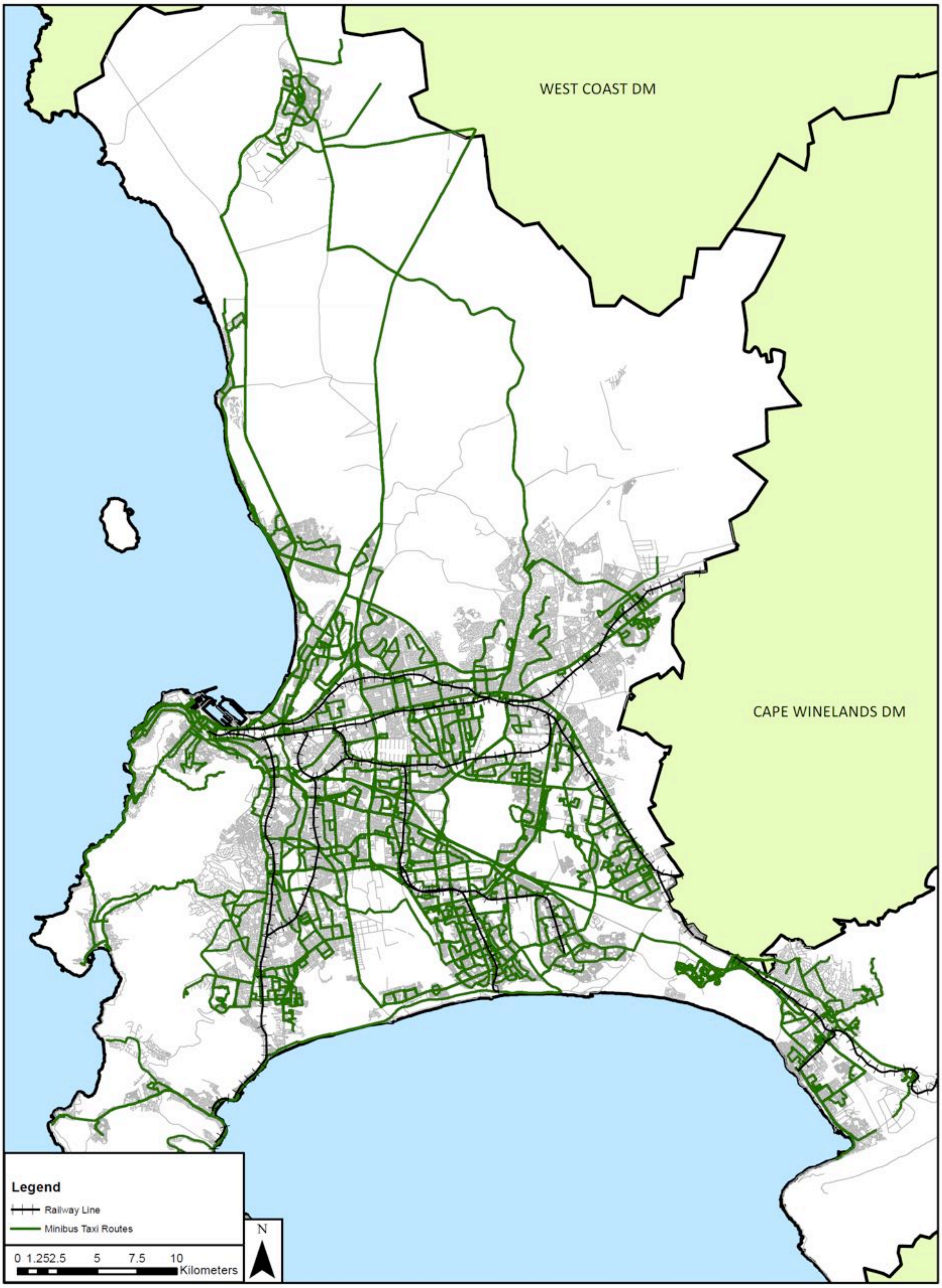


Figure 2-2: Roads used by Minibus Taxi

2.5.1.3 *Public Transport Facilities*

The City manages 58 of the 213 (formal and informal) public transport interchanges and ranks across the Metro. There are 43 minibus taxi ranks that have shelters with 983 parking bays available. 85% of the ranks have toilets and lighting. The management includes stakeholder engagement, cleaning and maintenance services. Although the larger ranks have been sited close to railway stations and bus termini they have not been fully integrated as public transport facilities, due to development having taken place by means of incremental upgrading. Many of the minibus taxi ranks and facilities have developed as demand has grown and as land has become available for development. Ranks vary from kerbside embayments to sheltered ranks with loading aisles, holding areas and wash bays with lighting and ablutions. Ranks and public transport facilities in the city are generally unattractive due to lack of maintenance and inadequate operational funding. Municipal by-laws at the transport facilities are enforced by a dedicated law enforcement unit. This team is supported by CCTV cameras installed at the main public transport interchanges, which are monitored by Metro Police.

2.5.1.4 *Fleet*

The 2013 CITP of Cape Town indicates that Minibus Taxis convey approximately 13% of all daily commuters into the CBD and 27% of public transport passengers. These services are provided by approximately 7 258 vehicles with valid licences. There are a number of illegal vehicles also operating. The 2007 OLS estimated that 46% of all taxis operating in Cape Town are illegal which roughly indicates that it is possible that approximately 13 500 (7 258 legal and 6 242 illegal) taxis are operating in the City. The average age of the Minibus Taxi fleet is estimated to be about 10 years.

2.5.1.5 *Ownership*

Each Minibus Taxi is privately owned. In the Minibus Taxi industry most vehicles are not operated by the owners. In many cases one owner owns many vehicles and outsources the operation of the vehicles to drivers on a daily basis. Drivers usually have an agreement with the taxi owner to use the vehicle on a daily basis for a set fee. Drivers are also responsible for fuel and any fines incurred while the owner covers all other vehicle related costs.

2.5.1.6 *Type of Operations*

The Minibus Taxi service operates on demand. Peak periods for the industry are on week day mornings and afternoons and on Saturday mornings. During peak hours due to the high passenger demand, operators try to do multiple trips. The week day morning peak period starts as early as 05:00 in some areas and ends at approximately 09:00. The evening peak starts at around 15:30 and ends at around 19:00. Some operators service the student demand on weekday afternoons. The industry provides a contracted or chartered shuttle service for staff of businesses which operate outside normal public transport operating hours. These services are operated either on an ad-hoc basis or on a contracted basis. Routes for these services are usually determined by the client.

2.5.1.7 *Taxi associations*

There are 102 registered Minibus Taxi route associations in the Metro. Most of the associations are affiliated to one of the four larger umbrella bodies, CATA, CODETA, PTA and Mitchells Plain. These umbrella bodies are not registered as taxi associations with the Registrar and do not have a constitution but their individual associations do have constitutions and are registered with the Registrar. The umbrella bodies usually determine fare increases for their members and also decide on strikes. Drivers are employed by the taxi vehicle owners on an ad hoc basis with very few benefits. The owners are affiliated to the associations which are in turn affiliated to one of the umbrella bodies.

2.5.1.8 *Operational Costs*

From surveys and workshops conducted by the City of Cape Town over the last three years, operational cost information was gathered from the taxi industry operating in the area affected by MyCiTi Phase 1A. From the data and assumptions the average operating costs for a Minibus Taxi was calculated. This rate is lower than the AA rate for a 16 seater vehicle. The City's assumptions were based on a vehicle cost of R160 000 repaid over a 7 year period whereas the AA used a vehicle cost of R270 000 over a 4 year period. The AA rate also allowed for garaging of the vehicle which increased its rate.

The income per taxi per km varies according to the length of the route, the fare and the passenger turnover. The surveys in the Phase 1A area provided an indication of an average income per kilometre. Using these figures, the net income per vehicle was calculated, which must cover the wages of the driver and the profit of the vehicle owner (before tax).

2.5.1.9 *Operating licence procedures*

In order to obtain a Minibus Taxi operating license, legislation requires that a prospective operator must either be a member of a taxi association which is registered (fully or provisionally) with the Provincial Transport Registrar or a non-member who is registered with the Registrar. The Registrar ensures that associations meet the requirements of the National Land Transport Act (NLTA). One of the key requirements of the Act is that each association must adopt a constitution.

2.5.1.10 *Utilisation*

Information is not available from boarding and alighting surveys on minibus taxi routes, so the percentage utilisation of vehicles along routes cannot be calculated. Cordon surveys which estimate the occupants in a vehicle as it passes a roadside survey person, indicate the taxis are usually full during peak hours in the peak direction of travel and empty on the return trip to collect more passengers. During the off-peak periods, taxis are generally half to two-thirds full. Boarding and Alighting

Boarding and alighting from taxis takes place at any point along the road side where passengers can wait, be picked up or dropped off. The concentration of boarding and alighting does however take place at transport interchanges and ranks. The 10 busiest taxi ranks according to a 2011 survey in terms of passenger movements are shown in Table **2-5** below.

Table 2-5: Busiest Minibus Taxi Ranks (TRS 2011 surveys)

No	Taxi Rank	All Day Pax
1	Bellville Station Transport Interchange	39 174
2	Nolungile Station Transport Interchange, Khayelitsha (Site C)	31 914
3	Cape Town Station Transport Interchange	27 618
4	Mitchell's Plain (Northern Transport Interchange)	21 652
5	Wynberg Station Transport Interchange (Western Side – Cape Town Route)	14 823
6	Nyanga Central Minibus Taxi Terminus	11 440
7	Retreat Station Transport Interchange (Western Side)	10 533
8	Wynberg Station Transport Interchange (Eastern Side)	6 781
9	Mitchell's Plain (Southern Transport Interchange)	6 215
10	Philippi (Joburg Stores) Lansdowne Road	6 151

2.5.1.11 *Safety and Security*

As with any mode, safety and security is considered an important aspect of the Minibus Taxi network. The City provides security at some of the key Public Transport Interchanges

2.5.1.12 *Current Projects*

The City is currently in the process of upgrading or preparing plans to upgrade the following Public Transport Interchanges:

- Bayside
- Bellville Hub
- Brackenfell
- Dunoon
- Durbanville CBD
- Inner City Hub
- Khayelitsha CBD
- Lentegeur & Mandalay station
- Macassar
- Mitchell's Plain station
- Nolungile
- Nomzamo
- Nyanga

- Retreat
- Somerset West
- Vuyani
- Wallacedene
- Wynberg Hub

2.6 Conventional Bus System

Conventional bus services, as distinct from BRT services, are provided in Cape Town by two privately owned operating companies, namely Golden Arrow Bus Services (GABS) Pty (Ltd) and Sibanye Pty (Ltd).

GABS currently operates 2 645 reported routes in the City. However, many of these include variations to the main corridor route. An example of this is the Route 44, which operates "generally" between Nyanga/Gugulethu and Bellville via the Airport Industrial Area. However this route has 11 different variants that serve either alternative origins and destinations or additional deviations to serve adjacent areas.

The extent of the routes operated by GABS and Sibanye is shown in Figure **2**-**3** which, in general, provides coverage throughout the city through mainly direct origin to destination services with few transfer opportunities.

It is largely due to the competition with the minibus-taxi, that buses, in cases from less dense areas, can follow indirect routes through areas to gain a higher coverage. If the public transport system was integrated the buses should follow a more direct route with feeder or local routes bringing the passengers to points on the main route. Generally the passenger flow is very directional, with movement towards work places in the morning peak and toward the residential areas in the afternoon, which results in inefficient operations. Off peak services are mainly for shopping, medical and administration (running errands) journeys.

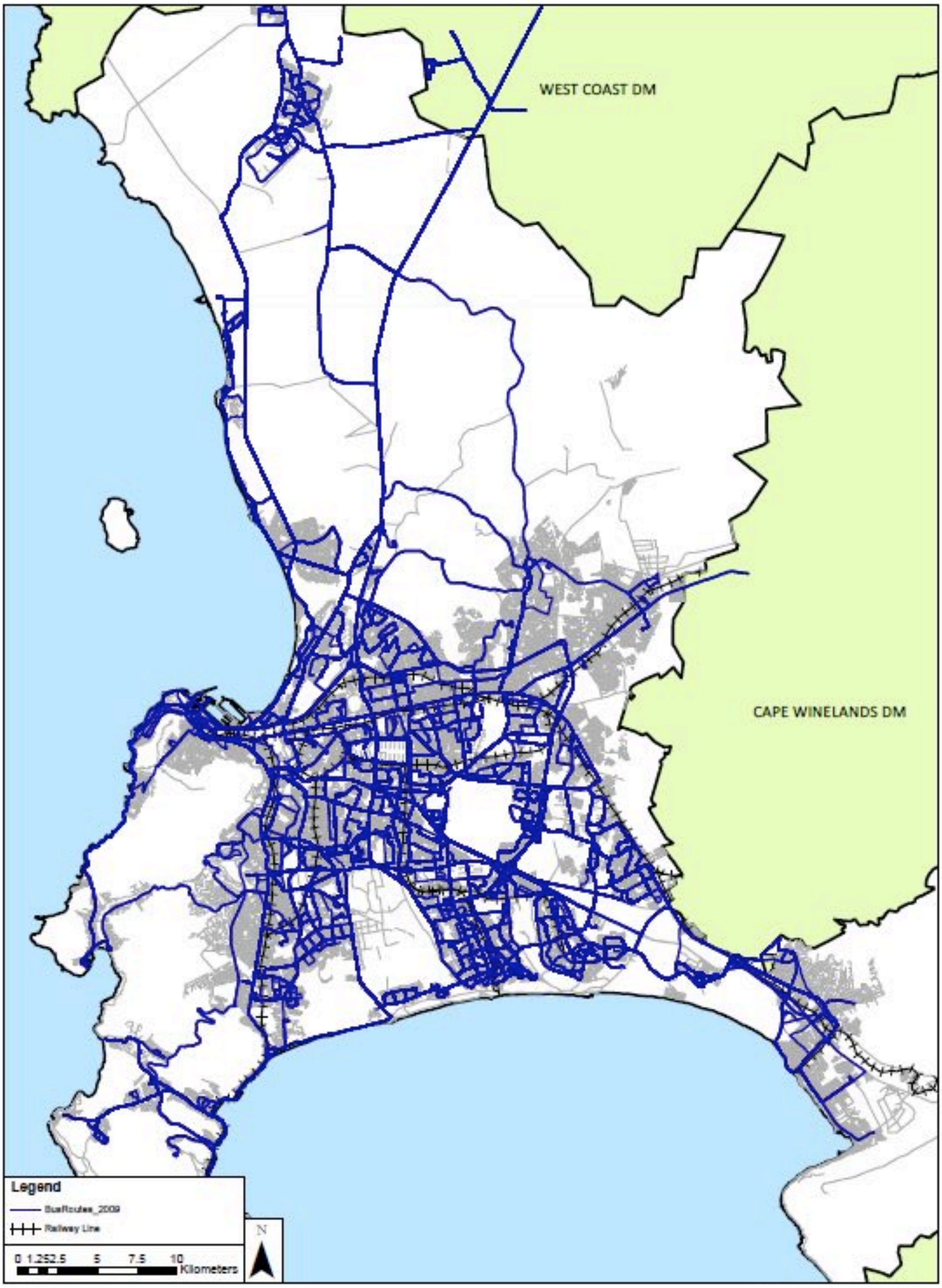


Figure 2-3: GABS and Sibanye Bus Route Coverage

2.6.1.1 *Facilities*

Scheduled bus services operate from a number of different types of facilities ranging from a simple bus stop sign placed on the side of the roadway without shelter or embayment, to well-developed off-street bus terminals such as Golden Acre and Mitchell's Plain. There are about 134 facilities that are classified as being bus termini, which are the origins and destinations of the bus routes. These are shown in Figure **2**-**4** below.

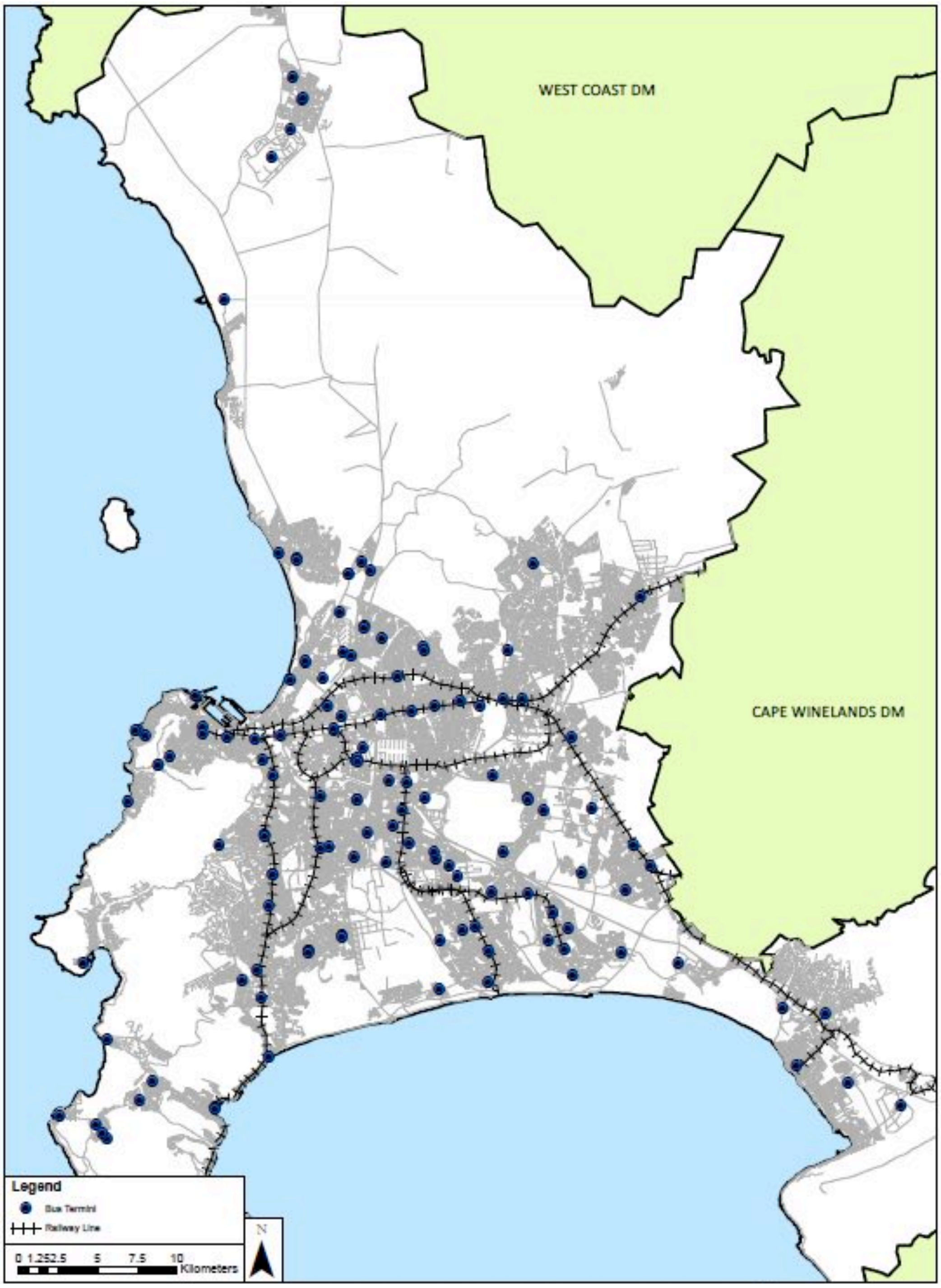


Figure 2-4: Bus Terminus Locations

2.6.1.2 *Service type*

The services provided by the bus operators are direct services that link one or more origin areas to one or more destination areas. It would be expected that transfers, from bus to bus, are very limited in areas other than the major terminals such as Golden Acre, Khayelitsha, Mitchell's Plain and Bellville, to name a few. The extent of such transfers could be confirmed once the data from the various surveys is analysed.

2.6.1.3 *Right of Way*

The City has a network of existing and proposed Bus and Minibus-Taxi (BMT) lanes. In terms of the City by-laws and regulations, both buses and minibus taxis are permitted to use these lanes. 25 km of BMT lanes in the Metro have been implemented on five arterial roads and one freeway within the metro. 19,45 km have been proposed and 13.34 km of extensions to existing BMT lanes are being planned. These are shown in Table **2-6**.

Table 2-6: Existing and Future BMT Lanes (source: ITP 2011)

Existing BMT Lanes			
Road	**From**	**To**	**Distance (km)**
N2 Freeway (In Bound)	Borcherds Quarry	Liesbeek Parkway	11,24
Klipfontein Road	Klipfontein Road	Athlone Terminal	3.37
Vanguard Drive	Klipfontein Road	Gunners Circle	3.99
Modderdam Road	Borcherds Quarry Road	De La Rey Road	1.9
Lansdowne Road	New Strandfontein Road	Wetton Circle	052
Main Road	Russel Street	N2	3.98
		Total	**25.0**

Proposed BMT Lanes			
Road	**From**	**To**	**Distance (km)**
Ottery Road	Strandfontein Road	Rosmead Avenue	4,41
Strandfontein Road	Spine Road	5th Avenue	5.03
Turfhall Road	Vanguard Drive	Flamingo Crescent	3.30
Wetton Road	Strandfontein Road	Rosmead Avenue	3.49
Lansdowne Road	Prince Arthur Road	Palmyra Road	3.22
		Total	**19.45**

Extension to BMT Lanes			
Road	**From**	**To**	**Distance (km)**
N2	Christiaan Barnard	Liesbeek Parkway	5.72
Klipfontein Road	Athlone Terminal	Liesbeek Parkway	3.03
Klipfontein Road	NY1	Heideveld Avenue	2.18
Vanguard Drive	Gunners Circle	Voortrekker Road	2.41
		Total	**13.34**

While the lanes have been implemented with road markings and signage on the above six roads, enforcement currently only takes place on two roads, namely Main Road between Russel Street and Settlers Way and along the N2 Inbound BMT Lane.

2.6.1.4 *Depot, staging and holding*

The conventional bus operators operate out of the following depots:

GABS:

- Arrowgate Depot – Pallotti Road, Montevideo
- Tollgate Depot – Victoria Road, Woodstock
- Philippi and Southgate Depots – Sheffield Road, Philippi
- Eastgate Depot – Waggie Road, Blackheath
- Simonstown Depot – Red Hill Road, Simons Town
- GABS Head Office – Bofors Circle, Epping Industrial

Sibanye:

- Atlantis Depot – Christopher Starke St, Atlantis Industrial
- UCT Jammie Shuttle Bus Parking – C Parking Ring Road, Main Campus

2.6.1.5 *Operational Statistics*

The 2013 CITP indicates the operational statistics, shown in

Table **2-7** below for the services operated by GABS and Sibanye.

Table 2-7: GABS and Sibanye Operational Statistics (CITP, 2013)

ITEM	GABS	SIBANYE
Fleet size	1 056	78
Peak (buses)	971	72
Departures per day	5 198	262
Departures per week	29 337	1 521
Passengers carried per day	220 028	19 972
Passengers carried per year	39 635 309	3 956 450
Kilometres travelled per year	36.6 million	3 897 198
Number of routes operated	2 269	155
Average trip length (km)	30.7	48.01
Staff employed	1 355 drivers	82 drivers
	2 645 total	95 total

The 1134 buses that are operated by GABS and Sibanye are predominantly high-floor vehicles with steps that are not easily accessible to persons with disabilities. The company has recently purchased a few low-floor demo buses with which they are currently running trials. The average age of the existing fleet is 10 years, as reported in the 2012 Annual Report of the holding company (HCI)[1]. During 2011/12 the company replaced 93 of its fleet with new buses at a total cost of R141 million.

2.6.1.6 *Ownership*

The companies that currently operate the majority of the scheduled bus services in Cape Town are Golden Arrow Bus Services (PTY) Ltd (GABS) and Sibanye Bus Services (PTY) Ltd through various contracts. Both are private companies.

2.6.1.7 *Scheduled Services*

Subsidised bus services are provided by the two operating companies namely Golden Arrow Bus Services (Pty) Ltd and Sibanye Bus Services (Pty) Ltd under interim contracts with the Provincial Government of the Western Cape: Department of Transport and Public Works (PGWC) which is the current contracting authority. This interim contract is currently being renewed on an annual basis. The CoCT has applied for the National DoT to assign the function of contracting authority to the City. Once this is gazetted TCT will negotiate this contract in terms of the parameters of the IPTN.

2.6.1.8 *Operational Costs*

Information on the annual operating cost and fare revenue is currently not available. A subsidy is allocated in the Division of Revenue Act for the by DoT to PGWC for the contract payments to GABS.

2.6.1.9 *Operation licences*

Bus operators are required by the NLTA to obtain operating licences authorising their operations over the identified routes. GABS are authorised to operate the following services with the specified conditions (summarised):

- Organised Parties,
- Bus Routes within the magisterial district of Cape Town,
- Charter Services to a radius of 240km from the areas served in the description above,
- Conveyance by tender or contract
  - -for any industrial concern in the above areas
  - -for persons attending social functions or other places of amusement
  - -for persons attending hospitals or clinics for medical care
- Generic service and or duty related conditions, stipulating:
- That the OL would be cancelled summarily on the interim contract being replaced by a negotiated contract,
- That the OL is only valid for 5 years, if the interim contract is not replaced by the negotiated contract.
- If the services intended by the interim contract is amended in anyway the PRE must amend the OL
- The services must be provided in accordance with the Vehicle Operator Agreement.

The above authority allows the operator basic free reign over what, where and when they wish to operate. For instance, all the GABS OL's do not specifically exclude the routes on which the IRT is currently operating thus legally permitting GABS to operate in competition to the City's highly subsidised system. The 2013 Operating Licence Strategy will propose a strategy for the City to make amendments to this authority and correct issues that may become critical in the future.

2.6.1.10 *Passenger demand*

A census by GABS in 2012 revealed that approximately 245 000 passengers per day are being carried on 5313 bus trips per day which are made on 1997 bus routes. Approximately 48% of these passengers were carried in the morning peak period (06:00 – 09:00). The 10 busiest routes and passengers carried per day are shown in

Table **2-8** below:

Table 2-8: GABS Busiest Routes (2012)

GABS Code		Route Description	Bus Trips/Day	Passengers/Day
1	PAS4	Atlantis-Cape Town	21	1866
2	MBC4	Mitchells Plain – Tyger Valley Centre	17	1669
3	OPY6	Cape Town – Tafelsig Lost City	22	1488
4	OPA1	Cape Town – Mitchells Plain via N2	28	1420
5	ADA9	Cape Town – Bellville via Voortrekker Rd	31	1303
6	EGF0	Nyanga Terminus – Cape Town via N2	14	1290
7	KCA2	Makhaza – Claremont	20	1248
8	KCA3	Claremont – Makhaza	21	1244
9	OPK4	Mitchells Plain – Cape Town via N2	16	1184
10	OPR6	Bayview – Somerset Hospital via Strandfontein	15	1146

2.6.1.11 *Safety and Security*

The bus operator provides its own security for its asset protection at the depots and its privately owned facilities, but not security for the passengers at the PTI's, terminals, bus stops, or on board the buses which is either non-existent or is provided by the City as part of its PTI management service.

2.7 MyCiTi Integrated Rapid Transit (IRT) bus system

The City of Cape Town is in the process of implementing Phase 1 of the IRT bus system, branded as MyCiTi. The characteristics of the system are based on the Bus Rapid Transit trunk and feeder concept as developed in South America and advocated by the Department of Transport in the national Public Transport Strategy (2007). These characteristics include dedicated bus lanes with priority control at road intersections, level boarding for passengers and pre-boarding fare validation.

The MyCiTi system consists of a network of trunk services that operate in median dedicated bus ways with central, high floor, closed stations, and a network of feeder services that feed/distribute passengers to and from the trunk stations. An integrated fare management system has been implemented that makes use of smartcard technology and calculates the fares based on distance travelled. Passengers are able to transfer between various routes without having to pay an additional boarding charge.

Phase 1 of the IRT encompasses the West Coast Region of the City along the R27 between Atlantis in the North to the CBD and southwards to Hout Bay along the Coast via Camps Bay, as well as a route from the Civic Centre to the Airport. There are currently two trunk routes running in dedicated lanes between Dunoon and the Waterfront via Tableview, and between Atlantis and Omuramba via Tableview and a network of 22 feeder routes which interface at various stations along these routes. The trunk and feeder routes currently in operation (May 2014) are shown in Figure **2**-**5**.

The City is busy constructing another trunk route along Koeberg Road which will provide connections to the existing trunk routes at Dunoon and Omuramba, as well as extending the feeder network eastwards from Century City. A new express service will also be introduced in 2014 along the N2 from the Civic Centre to Khayelitsha and Mitchells Plain.

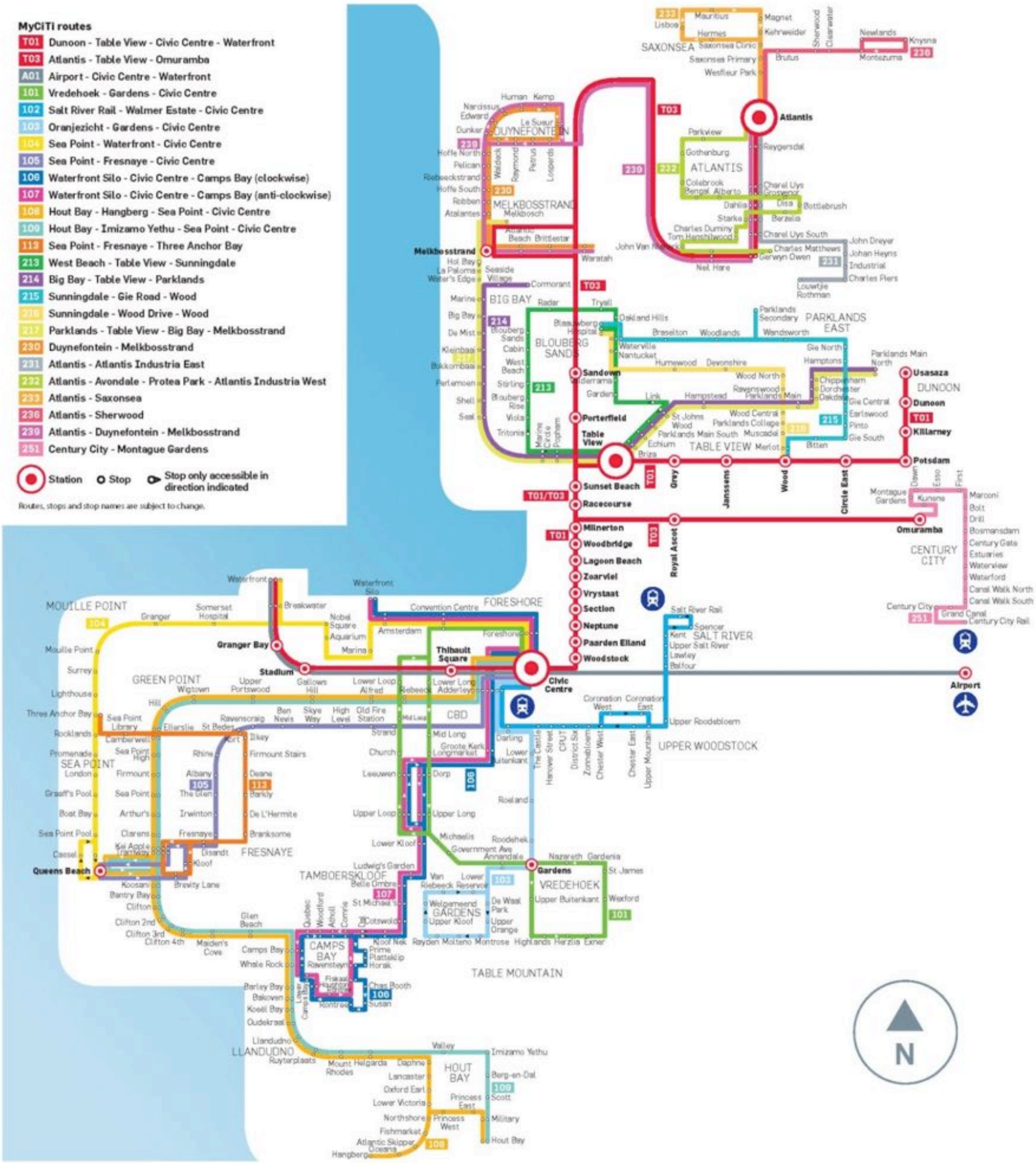


Figure 2-5: MyCiTi Routes in operation (May 2014)

The enclosed stations in the medians along the trunk routes are steel framed with glass sides and sliding doors create a safe, comfortable, and secure environment for patrons of the MyCiTi services waiting to board buses. The stations each incorporate a ticket sales kiosk and amenities for maintenance and use of the staff. However, it has been noted that passengers wishing to purchase tickets have to queue outside the station and are thus exposed to inclement weather. Future station design will need to consider this and ensure that sufficient weather protection is afforded.

2.7.1.1 *Depots and staging*

The City has established three depots and one staging area for the Phase 1 operations, as follows:

- Prestwich Street Inner City Depot
- Stables Depot, Du Noon
- Atlantis Depot, Atlantis
- Foreshore Staging Area, Table Bay Boulevard.

2.7.1.2 *Fleet*

The current and proposed MyCiTi network is an integrated system that is operated by a mix of different types of fully accessible buses, consisting of the following:

- 18 metre high floor articulated buses – trunk routes,
- 12 metre high floor buses – feeder routes,
- 12 metre high floor buses adapted for the Airport service,
- 12 metre low floor buses – N2 Express service,
- 9 metre low floor buses– feeder routes, and
- 6 metre minibuses – proposed

The 18 m and 12m high floor buses only have universal access through the right hand doors at the high platforms. Passengers boarding and alighting on the left had side have to mount steps to gain access to the bus. The 12m and 9m low floor buses are universally accessible with doors on both sides of the buses. The 6 m buses will initially not be universally accessible as they will be existing minibuses used by affected operators.

2.7.1.3 *Control Centre*

The City has constructed a Traffic Management Centre (TMC) in Smart Road, Goodwood. This centre is where all aspects of traffic management and emergency management are centred. Part of the centre is dedicated to the operations of MyCiTi. Key to the operations of the TMC is the linkage to all city and relevant government agencies CCTV systems. The Advanced Passenger Transport Management System (APTMS), which assists in the management and monitoring of MyCiTi operations and real time passenger information, is also controlled from the TMC.

2.7.1.4 *Scheduled Services*

All services provided on the MyCiTi system are fully scheduled with timetables being published on a website and prominently displayed at the stations and bus stops. In addition to this, the APTMS is designed to provide real-time information at stations, predicting the waiting time before the next departure on each trunk route. This information will not be available at the feeder bus stops.

Trunk services operate at an 8 minute headway during peak periods and at 20 minutes during rest of the day and over weekends. The airport service operates at a standard headway of 20 minute throughout the day. Feeder services have headways of between 10 and 15 minutes during peak periods and 20 to 30 minute headways for the rest of the day and over weekends.

MyCiTi services currently commence operations daily from approximately 05:30 and continue through to 22:00, depending on the route, however the Airport Civic Centre - Waterfront service begins at 04:05 and continues to 22:20.

2.7.1.5 *Contracted operators*

Currently three Vehicle Operating Companies (VOC's) have been contracted to provide the MyCiTi services on behalf of the City. The VOC's are comprised of consortiums of taxi associations and bus companies as indicated in Table **2**-**9**: Vehicle Operating Companies and Service Contracts below, where:

- Company A – Transpeninsular Investments (Pty) Ltd
- Company B – Kidrogen (Pty) Ltd.
- Company C – Golden Arrow Bus Services (Pty) Ltd.

Table 2-9: Vehicle Operating Companies and Service Contracts

Company A **(Inner City)**	**Company B** **(Blaauwberg)**	**Company C** **(Trunk and Inner City)**
1. Peninsula Taxi Association 2. Central Unity Taxi Association 3. Devils Peak Vredehoek Taxi Association	1. Blaauwberg Taxi Association 2. Maitland Taxi Association 3. United Taxi Association 4. Ysterplaat Taxi Association 5. Du Noon Taxi Association	1. Golden Arrow (scheduled bus service provider) 2. Sibanye (scheduled bus service)

	6. Sibanye (scheduled bus service provider)	
Contract 1 (Inner City)	**Contract 2 (Blaauwberg)**	**Contract 3 (Blaauwberg)**
• All inner city feeder services (including City – Hout Bay) • Airport – City trunk service • Portion of the trunk services based on the City's calculation of current market share between constituent parties allocated to the three contract areas	• All Blaauwberg feeder services (between Salt River and Atlantis) • Portion of the trunk services based on the City's calculation of current market share between constituent parties allocated to the three contract areas	• Portion of the trunk services based on the City's calculation of current market share between constituent parties allocated to the three contract areas • Portion of feeders in the Inner City area to make up the market share of the third operator

2.7.1.6 *Fare system*

The fare structure is a stepped distance based system in which the passenger pays a boarding charge on entering the system and then pays a distance based charged on exit from the system. The integrated fare management system, which makes use of smartcard technology (MyConnect card), permits transfers between the different services without additional cost, according to certain rules. Fares for services operating on different routes during 2013 are shown in Figure **2**-**6**below.

101 Civic Centre - Gardens	R5.30
102 Civic Centre - Walmer Estate - Salt River Rail	R5.30
Free transfer between these routes or to the Waterfront, via Civic Centre station	
T01 Civic Centre - Table View *Includes a free R5.30 trip at both ends*	R10.60
F14 Big Bay - Table View - Parklands East	R5.30
F15 Parklands East - Table View - Blouberg Sands	R5.30
F16 Marine Circle - Table View - Blouberg Sands	R5.30
Free transfer between these routes, via Table View station	
A01 Airport - Civic Centre - Waterfront	R62.30
Airport - Civic Centre	R57
Civic Centre - Waterfront	R5.30
Monthly ticket between Airport and Civic Centre	R449.50

Figure 2-6: Existing MyCiTi fares

2.8 Conclusions from Status Quo Evaluation

The main conclusions which emanated from the status quo review and evaluation of the City's public transport system, which have been used as input to the development of an Integrated Public Transport Network for the City, are summarised as follows:

1. The DOT's Public Transport Strategy (2007) states that long term goal is to develop a system that places over 85 percent of a metropolitan city's population within 1 km of an IPTN trunk or feeder route by 2020. Further goals in the Public Transport Strategy are for the metropolitan cities to achieve a mode shift of 20% of car work trips to public transport networks by 2020 and to reduce the door-to-door journey time of public transport users to a maximum of 60 minutes. While the goal of 85% population within 1 km of IPTN service may be achievable by 2020, the goals of 20% mode shift and maximum 60 minutes trip time are unlikely to be achieved by 2020, due to the size of Cape Town and the fact that more than half the current public transport users already have trip times longer than 70 minutes, according to the 2013 household survey results.

2. Although the passenger rail system operated by Metrorail is acknowledged by all authorities to be the backbone of the public transport system, it has reached its current capacity limit on critical sections of the network due to headway constraints resulting from an outdated signalling system, as well as insufficient and ageing rolling stock. Expansion of the capacity of the rail system is being addressed through a package of short term strategies by PRASA which include:

- Modernising the signalling system to reduce the headway between trains and thus reduce the train turnaround time and increase the overall capacity
- Providing passing lines at stations to enable more express and skip-stop services
- Replacing the ageing rolling stock and increasing the number of train sets in the City. PRASA has indicated that the first new trains will be delivered in 2016

but has not yet provided a programme for the expected number and rate of delivery of train sets to each city.

3. PRASA's strategy to extend the rail network in the next 10 to 20 years, as set out below in order of priority according to the PRASA Regional Strategic Plan (2012), needs to be changed in the light of travel demand modelling done for the IPTN.

- Atlantis corridor – A
- Fisantekraal corridor – A
- Blue Downs link – B
- Airport link – C
- Philippi – Southfield link – C
- Khayelitsha – Somerset West – C

The results of the household travel surveys and travel demand modelling shows that the passenger demand in the Atlantis and Fisantekraal corridors does not warrant commuter rail services in these corridors within the next 20 years. However, the travel demand in the Blue Downs corridor already warrants construction of a double track line. The City has already addressed a letter to PRASA in February 2013 requesting that the Blue Downs line be given top priority.

4. The Operational Plan for the IPTN must address the following issues:

- The location of modal interchanges to minimise the number of passenger transfers required.
- Optimisation of the fleet sizes for the trunk and feeder services to minimise operational costs.
- The methodology and timescale to transition from the existing conventional bus and minibus taxi operations to IRT operations with regard to integration of infrastructure, services and ticketing.

5. The network design target standards to be used for development of the IPTN are contained in the City's CITP and are shown in

Table 2-10 below.

Table 2-10: IPTN Network Design Targets (CITP 2013)

IPTN Design Targets							
	General	Level 1 (Trunk)		Level 2 (T/F)		Level 3 (Feeder)	
		Peak	Off-peak	Peak	Off-peak	Peak	Off-peak
Capacity (pass/hour/direction)		10 000 – 50 000		4 000 – 20 000		0 – 4 000	

IPTN Design Targets							
	General	Level 1 (Trunk)		Level 2 (T/F)		Level 3 (Feeder)	
		Peak	Off-peak	Peak	Off-peak	Peak	Off-peak
Headways (min.)		10	20	10	20	20	30
Route Spacings (km)		5		5		1	
Peak Duration (hr)		6		6		6	
Off-peak Duration (hr)			12		12		12
Maximum walking distance (m) (>80% of households)	500						
Maximum walking/cycle time (min)	15						
Maximum cycling distance (km)	3						
Maximum journey time (min) (>80% of passengers)	60						
Operational speed (km/hr)		30 – 70		20 – 30		5 - 10	
Stop / Station spacing (m)		1 000 – 2 000		500 – 1 000		<500	
Affordability	90% pay < 10% of income						

The capacity of 10 000 pass/hour/direction is the threshold for determining when a rail line is needed and has been used in the development and evaluation of the long term network alternatives.

3. Transport demand model: 2013

3.1 Introduction

The 2013 transport demand model for the City of Cape Town was developed as part of the Integrated Public Transport Network project and covers the City of Cape Town, Malmesbury, Paarl, Wellington, Stellenbosch and Franschoek (Figure **3-1**). The network and zone system of the previous model was used as base for the development of the 2013 model.

Figure 3-1: Area Covered by the Transport Demand Model

The Transport Demand Model is a tool to estimate the future travel demand patterns for different transport alternatives and the EMME4 software package, developed by INRO, was used to develop this Transport Demand Model.

A four step travel demand model was used for this demand analysis. A standard 4-step travel demand modelling process consists of four sub models:

1. Trip generation - how many trips are produced by and attracted to any analysis zone.
2. Trip distribution - how are these distributed between zones.
3. Modal split - what mode of transport is likely to be used for which trips.
4. Trip Assignment - which routes on the road network will be taken for which trips.

The 4-step modelling process can be shown graphically as follows in Figure **3-2**:

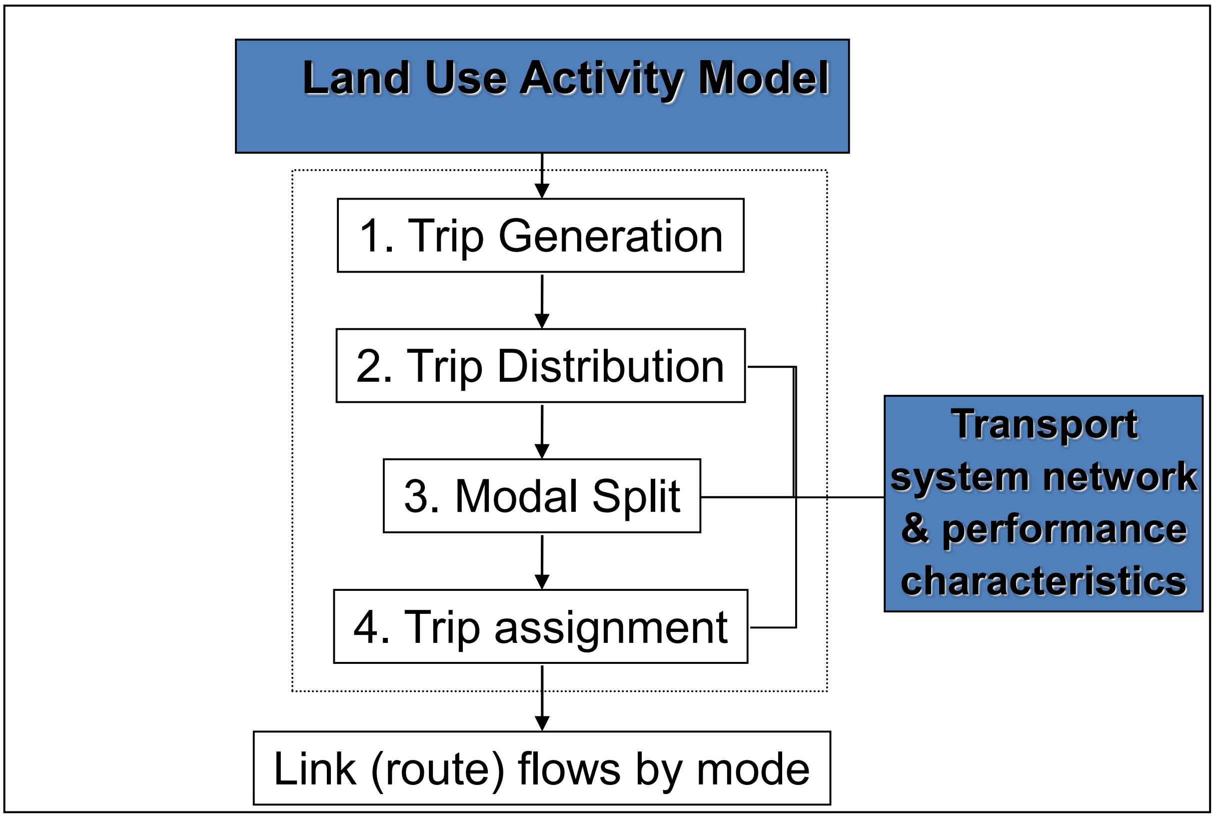


Figure 3-2: 4-Step Modelling Process

3.2 Zoning system and road network

3.2.1 Zoning System

In the model, a trip is defined as being between an origin and a destination, with each origin and each destination being represented as a Travel Analysis Zone (TAZ). Each TAZ is defined so as to represent a homogenous area in terms of land use and demographics, so that, on average, the trip generation characteristics for that area can be assumed to be homogenous.

The City's previous (2010) travel demand model's zone system was evaluated to assess its representativeness and homogeneity. Detailed adjustments were made within the LWC and adjustments were also made to the zones outside the LWC. These adjustments consisted of refinements to the zones in the LWC, improvements and corrections to zones outside of the LWC and defining sub regions (zone groupings) for assessments at a macro (more aggregated) level. Refinement of the zones within the LWC consists of subdividing the original zones and adjusting the original zone boundaries to fit natural and man-made restrictions where necessary.

Improvement of the current zones consisted of removing gaps between zone boundaries as well overlaps of zone boundaries (slivers). A substantial area was not covered by zones at all. New zones were introduced to cover these areas. Five sub regions were introduced, these are:

- 2010 zone definition (sub region ga) to be able to compare the matrices (trip tables) of the current model to matrices of the previous model
- Zones grouped according suburbs (sub region gb)
- Zones grouped according to the macro zone definitions (sub region gc)
- Zones grouped according to the planning districts (sub region gd)
- Zones grouped according to regions (sub region ge)
- Zones grouped according to major land uses (sub region gf)

The total number of zones increased from 1 376 in the 2010 model to 1 791 zones in the present model of which 8 are external zones (Figure 3). External zones do not cover an area as with the internal zones, but represents roads/railway lines that cross the border of the modelled area.

The sizes of the internal zones are such that they represent the density of development in that zone. High density areas are represented by small zones while rural areas are represented by large zones as shown in Figure **3**-**3**.

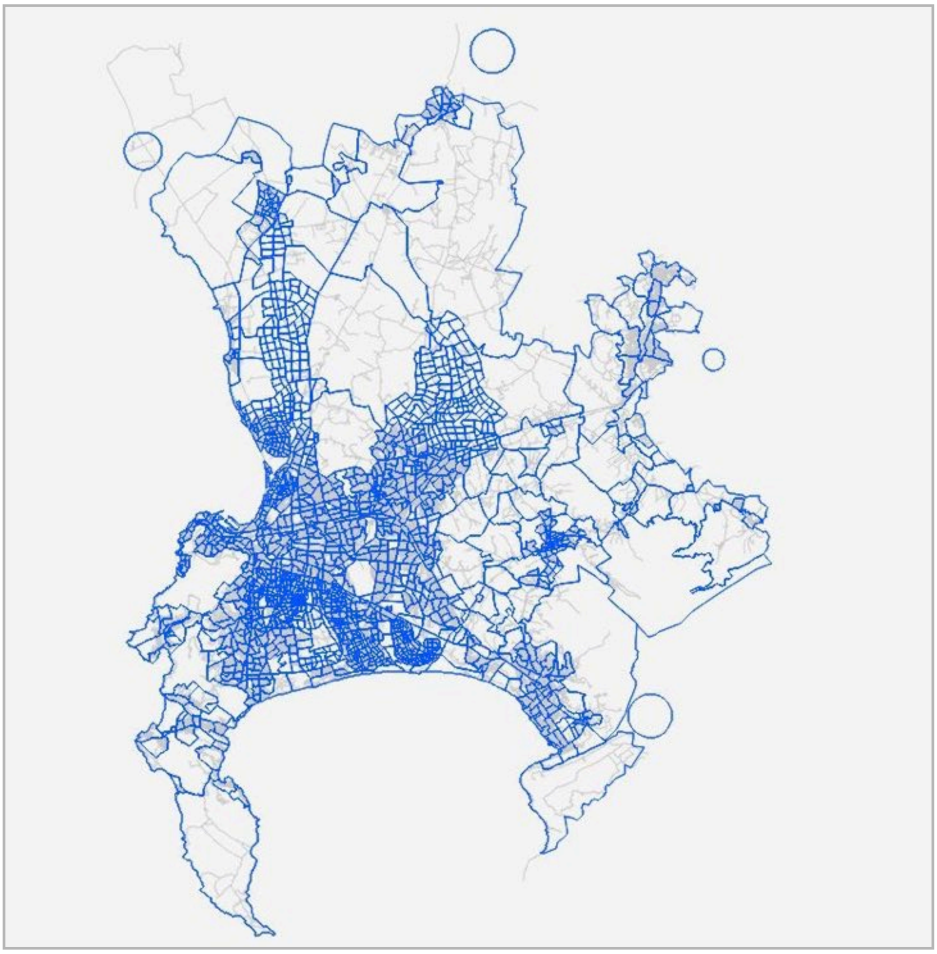


Figure 3-3: Refined Zone System

3.2.2 Current network

The current transport network has been classified into two components for modelling; namely, the private network and the public network. The private network consists of various categories of road links. The public network includes the main passenger transport modes, such as rail, bus, MyCiTi (BRT trunk and feeder) and unscheduled minibus-taxis. Although some cognisance of walk trips has been taken, this study did not include a detailed investigation into the non-motorised transport (NMT) network.

3.2.3 Private Network

In the model, roads are segmented into a series of links, which are connected to each other at nodes. Nodes are typically placed at intersections or stations. The private network in the model consists of various links. Each link was allocated specific link attributes to simulate its actual characteristics. The link parameters are:

- Link length (km)
- Link type
- Number of lanes

- Modes of transport using the links (walk, private vehicle, minibus-taxi, bus, MyCiTi and rail)
- A volume delay function describing how the delay on the link changes as the volume of traffic on the link changes
- Free flow capacity per lane
- Free flow speed on the link

The road types represented in the model are:

- Freeways
- Expressways divided
- Expressways undivided
- Arterials divided
- Arterials undivided
- Collectors (Class 4)
- Local roads (Class 5)

An example of the represented road network coloured by link type is shown in Figure **3**-**4**.

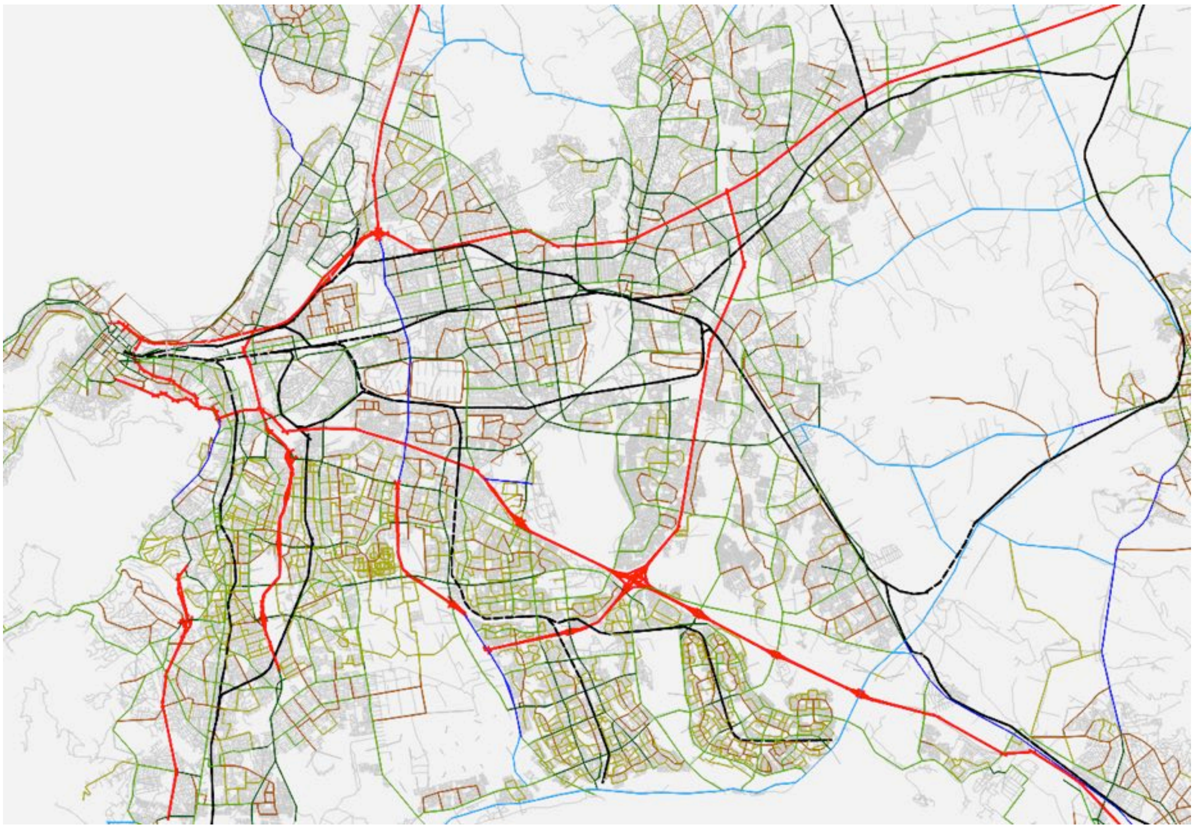


Figure 3-4: 2013 modelled road network coloured by link type

The network consist of 7 051 nodes and 21 588 links with a total link length of approximately 9 600 km. The breakdown per road type as represented in the model is provided in Table **3-1**.

Table 3-1: Breakdown of link per road type

Road Type	**Length (Km)**	**Percentage**
Freeways	426	6%
Expressways divided	95	1%
Expressways undivided	1 026	15%
Arterials divided	759	11%
Arterials undivided	1 731	26%
Collectors Class 4	1 268	19%
Collectors Class 5	1 394	21%

3.2.4 Public Transport Network

Public transport routes from the previous 2010 model were used as a base from which to develop the new model network, and only those routes applicable to the morning peak hour are included in the model. Only some of the bus and taxi routes to and from Stellenbosch could be obtained, whereas no public transport routes could be obtained from Franschoek, Paarl, Wellington and Malmesbury.

A total of 1 419 taxi routes are represented in the model. In the model, taxis stop at all nodes and an average dwell time (the time taken at each stop) of 19 seconds is used for each stop. This is 40% of the average bus dwell time, which was measured to be 48 seconds. The coverage of taxi routes are displayed in Figure **3-5**. A total of 1 999 331 origin-destination pairs (trip start and end locations) are serviced by the coverage of the taxi routes (this is 18% less than the private car mode). Headways and vehicle characteristics were the same as what was used in the 2010 model.

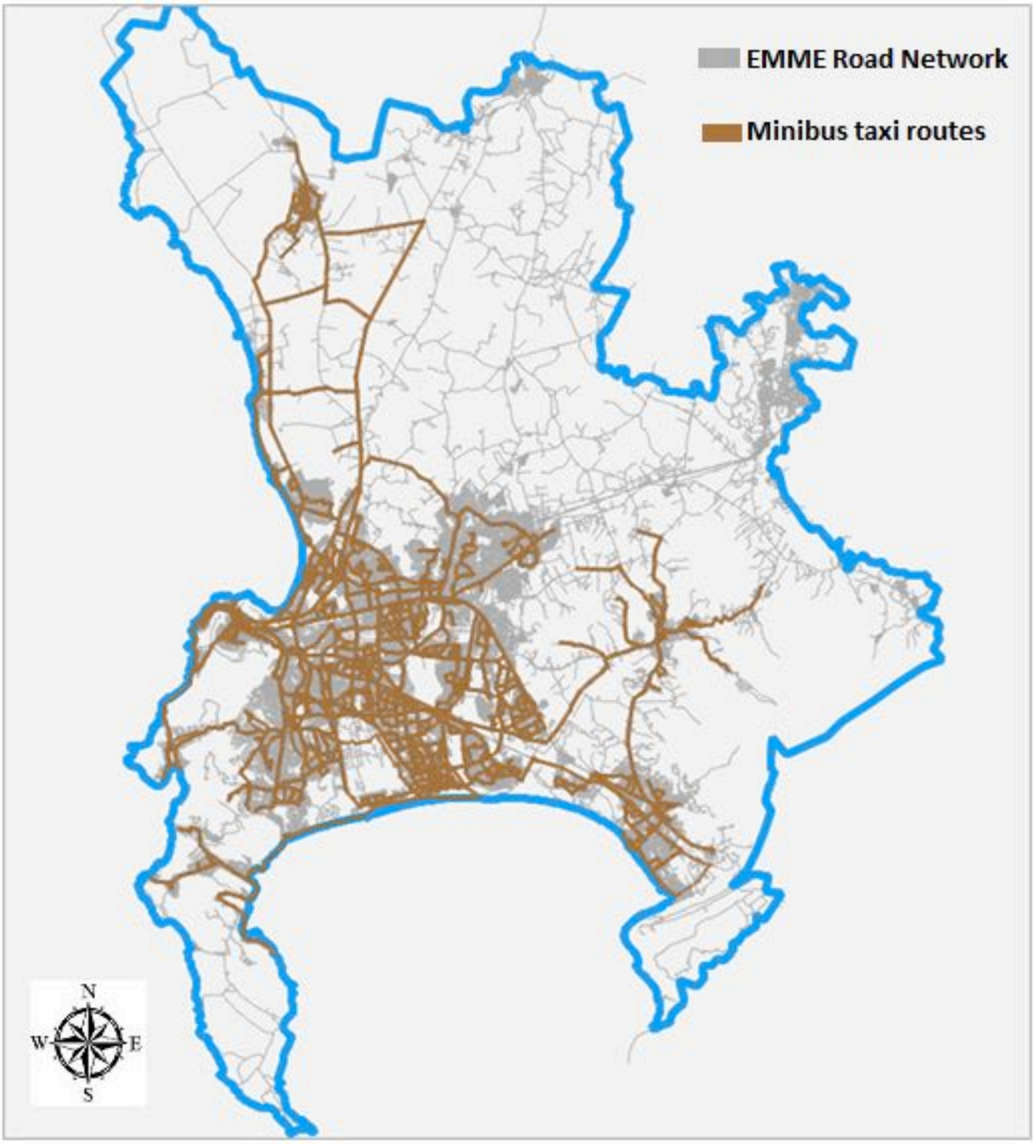


Figure 3-5: 2013 Coverage by Minibus taxi routes

998 Bus routes are represented in the model. The overall average dwell time for bus is 48 seconds. Bus stops in the model are only allowed at centroid (where zones are joined to the network) and transfer links (where bus and train routes overlap). Coverage of bus routes are displayed in **Error! Reference source not found.**. A total of 1 569 190 origin-destination pairs are serviced by the coverage of the bus routes (22% less compared to the taxi mode).

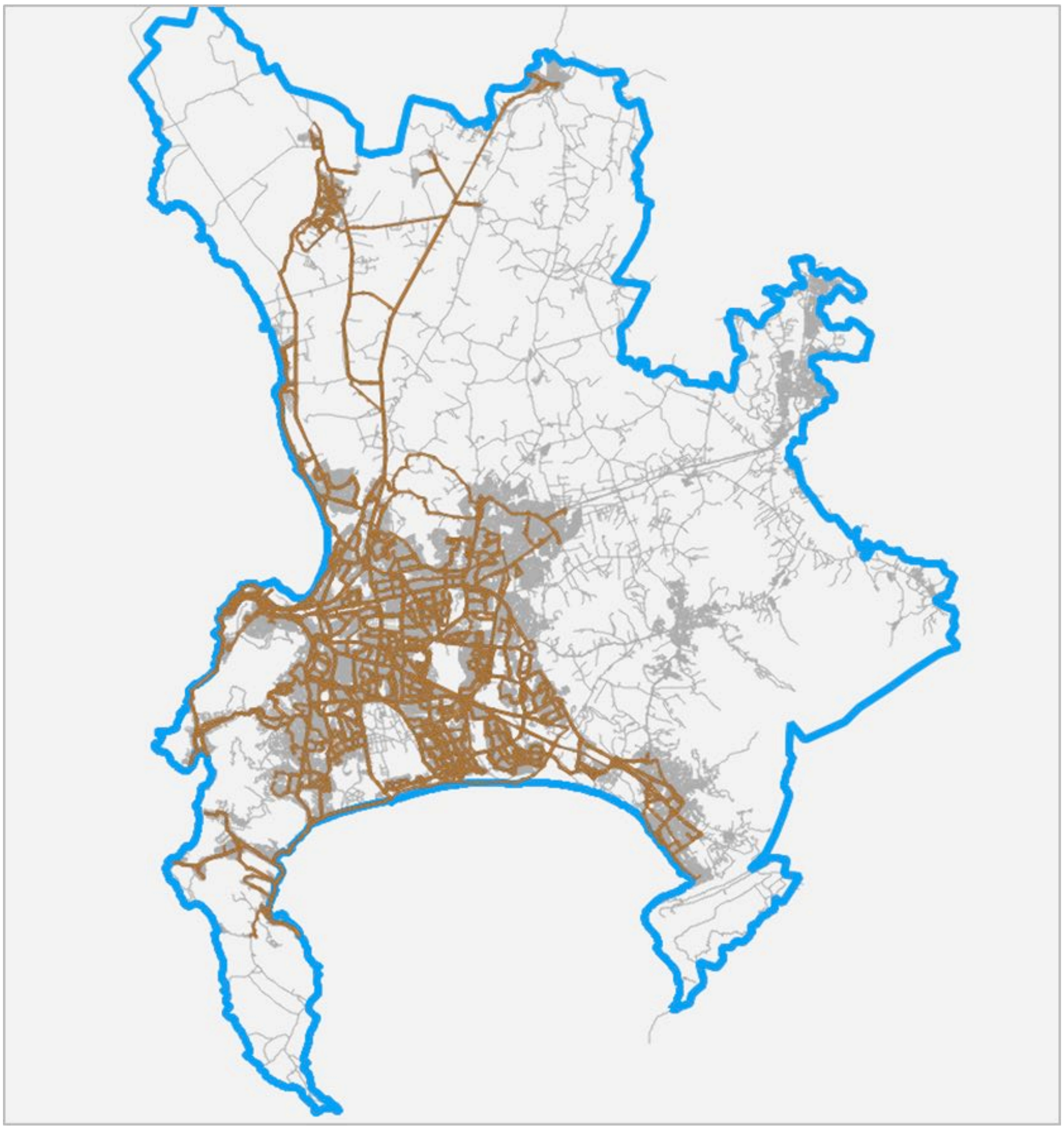


Figure 3-7: 2013 Coverage by Contracted bus routes

MyCiTi trunk and feeder routes were recoded as implemented at the time of the household survey, and include 14 routes (both trunk and feeder). The coverage of the MyCiTi service in the model is displayed in Figure **3-8**. A total of 11 872 origin-destination pairs are serviced by the coverage of the MyCiTi routes. The network was carefully assessed to ensure that all movements and transfers are possible.

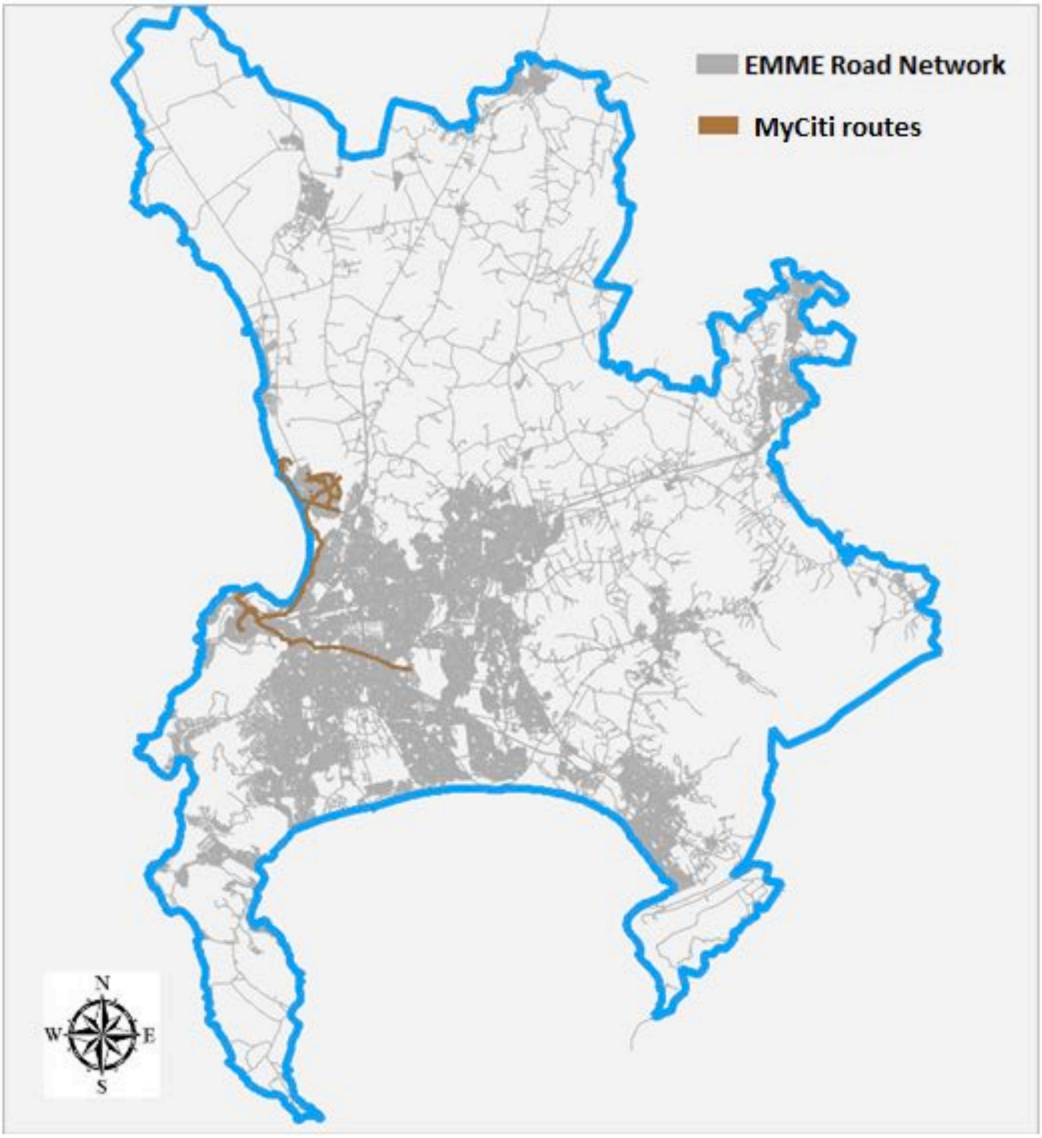


Figure 3-8: 2013 Coverage by MyCiTi routes

A total of 62 rail services are represented in the model. Trains in the model are allowed to stop as per the stations in the timetable. An average dwell time of 1.3 minutes per station was used. The coverage by rail services is displayed in Figure **3**-**9** (covering 482 856 origin-destination pairs).

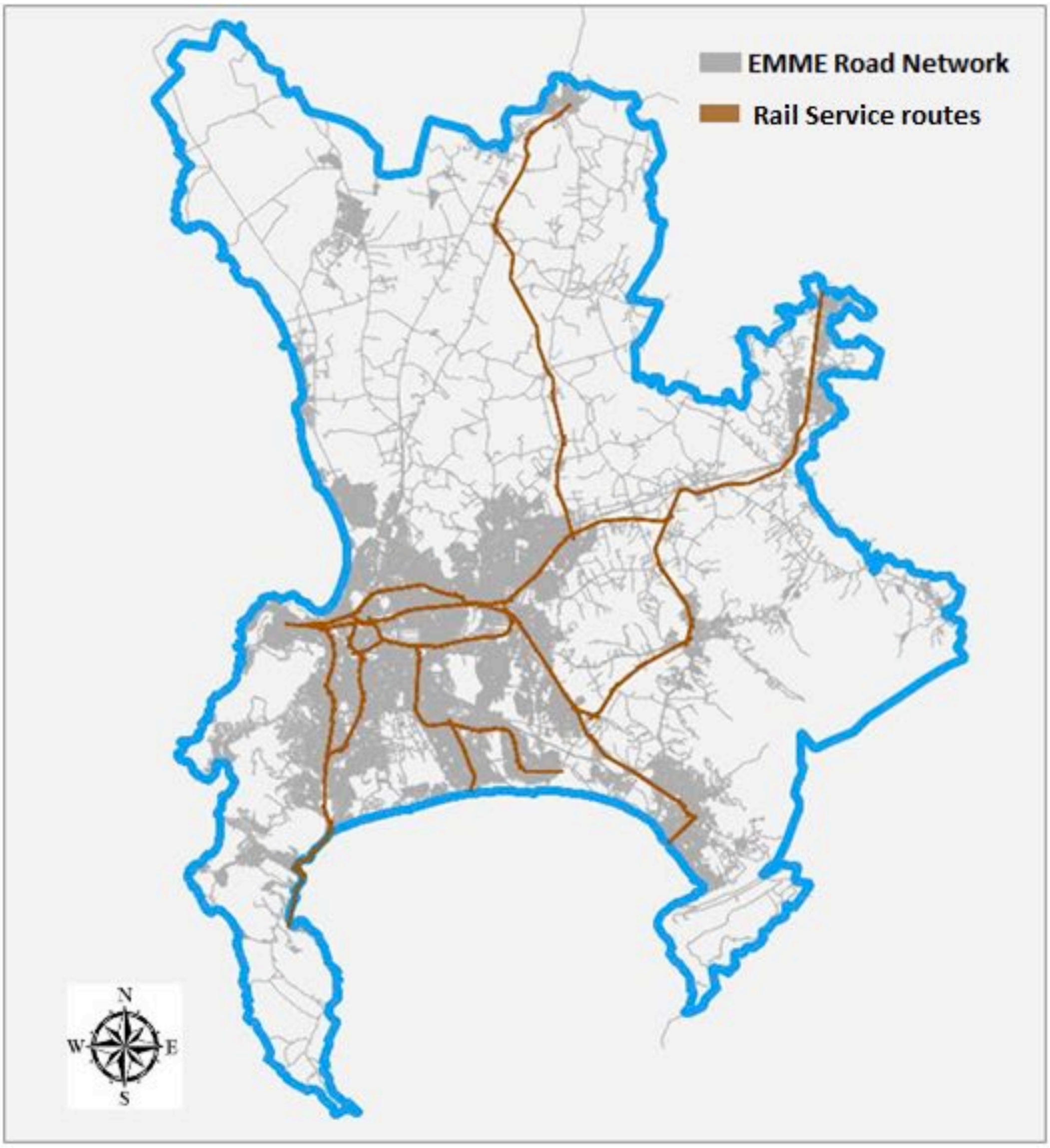


Figure 3-9: 2013 Coverage by Rail Services

It was found that there are a number of route duplications for both taxi and bus modes and that a significant amount of overlapping exists between bus and taxi modes.

3.3 Demographic inputs

3.3.1 Population

The 2011 Census Data was used to calculate the population per traffic zone by applying a two-year growth factor. The total estimated 2013 population for the area covered by the model is 4.1 million persons and the population per income group is displayed in Figure **3**-**10**.

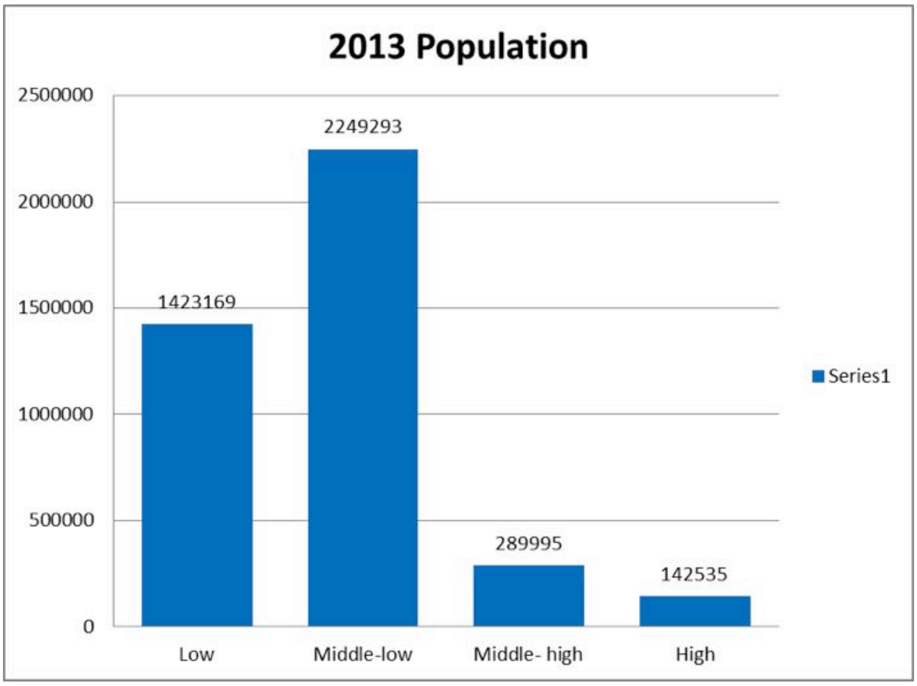


Figure 3-10: Distribution of 2013 population between income groups

The Household Travel survey data was used to split the population between the four defined income groups and the different population categories. The four income groups used were low, middle-low, middle-high and high income.

The population categories are:

- Employed people: which is further divided between full-time, part-time, self-employed and construction workers
- Unemployed people: which is further split between those persons not looking for work and those persons looking for work
- Pensioners
- Students: which is further split between schools (including primary and secondary) and tertiary education
- Housewives and homemakers
- Children younger than 6 years of age

The split between the various population categories for each of the above income groups is shown in **Table 3-2.**

Table 3-2: 2013 Population per Category and Income Group

Category	Income	Income	Income	Income	Total
Employed (full time)	262 318	795 310	114 349	50 279	**1 222 256**
Employed (part time)	44 472	55 497	4 062	3 111	**107 142**
Employed (self)	35 371	101 833	38 659	26 981	**202 845**
Unemployed (not seeking work)	138 897	100 559	6 491	3 174	**249 121**
Unemployed (seeking work)	276 007	189 541	5 376	3 662	**474 586**
Employed (construction)	18 280	25 984	1 311	170	**45 745**
Pensioner	218 404	256 385	27 985	8 523	**511 297**
Student (tertiary)	23 545	52 883	27 985	8 384	**96 431**

Student (primary & secondary)	166 621	289 215	37 314	18 583	**511 733**
Housewife	72 957	133 671	16 705	7 587	**230 920**
Less than 6 years of age	166 295	248 415	26 126	12 081	**452 917**
Total	**1 423 169**	**2 249 294**	**589 995**	**142 536**	**4 104 994**

3.3.2 Employment

The employment categories used in the model are:

- Office workers
- Retail workers
- Manufacturing workers
- Warehouse workers
- Service workers
- Community workers
- Construction workers
- Transport workers
- Recreation workers
- Agricultural workers
- Education (scholars, tertiary students and personnel)

Employment estimates for these categories was made from data provided by the City. The estimated employment figures per income group are shown in Figure **3**-**11**:

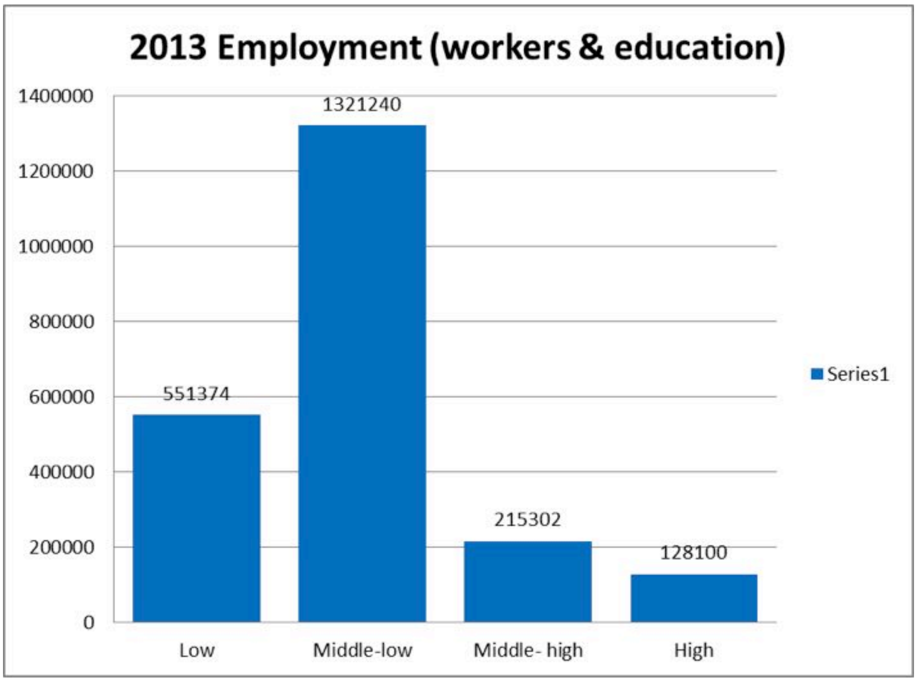


Figure 3-11: Distribution of 2013 employment between income groups

It was estimated that a total of 1 577 989 people are currently employed of which 37% are in business, 46% in industry, 14% in community services, 3% in education and 1% in other categories.

3.3.3 Trip table segmentation and model structure

In the model trips are represented as being between an origin zone, and a destination zone, with the "OD-pairs" being combined into a trip table, known as an OD-matrix. OD-matrices are further segmented into categories of trips, defined by the trip purpose, income group and the main mode of transport for those trips.

Three trip purposes were modelled including work trips, education trips and "other" trips. Other trips include trip purposes such as shopping and social, amongst others. Since the model is only for the morning peak hour these "other" trips only play a small role in the results.

As mentioned, trips are split by trip purpose and also by income group. Trips are then further split between the six modes of transport including walk, private vehicle, minibus taxi, contracted bus (primarily GABS), MyCiTi and rail. This produces a large number of OD-matrices.

The model structure is shown in Figure **3-12** below.

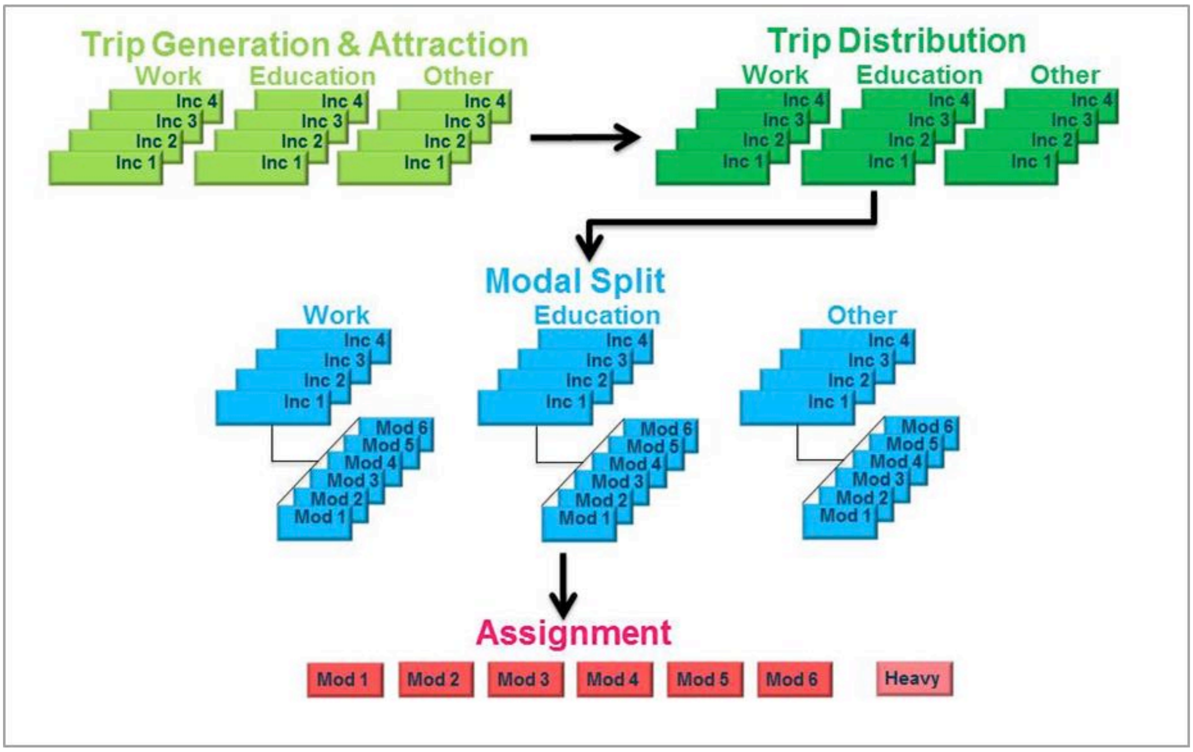


Figure 3-12: Model Structure

The first three steps of the model, being trip generation, trip distribution and modal split, are undertaken for the morning peak period (3 hours) and final step, trip assignment, is done for the morning peak hour, with the trips used here being extracted from the 3-hour peak period. This is because transport demand models are developed for the busiest hour of traffic since transport systems are designed to cater for the peak hour of a normal weekday.

3.3.4 Model Overview

Enhancements to the previous model (2010 City of Cape Town Transport Demand Model) include the following:

- Zonal refinements
- Network refinements
- Socio economic refinements with regards to the population and employment categories as well as the number of income groups
- Traffic generation improvements
- Modal split improvements
- Trip distribution improvements
- Trip assignment improvements
- Model Calibration and Validation

This resulted in a model that can be applied to test the following:

- Changes in the distribution of population between four income groups
- Changes in population composition in terms of the employment categories
- Changes in employment composition in terms of the employment categories, including changes in unemployment.
- Refined zones imply that matrices can be transferred from the EMME model to micro simulation models with the minimum effort.
- The refined zone system makes provision for future zones to accommodate future population and employment in the model.
- The impact of proposed new future roads can be determined
- The impact of the upgrading of existing roads (in terms of number of lanes and road class) can be determined.
- The model outputs can be used for economic evaluation of proposed improvements.
- The impact of the termination of public transport modes (taxi, contracted bus, MyCiTi and rail) can be determined.
- The impact of changes in public transport routes (termination of routes, introduction of new routes or the re-alignment of routes) can be determined.
- The impact of improvements or deterioration of public transport services in terms of the travel time, walk time, wait time, number of transfers and cost can be determined.
- The introduction of three trip purposes (Home-based work, Home-based education, Home-based other) provides better insight into the traffic composition.
- The trip generation and attraction model introduced is more sensitive to changes in population and employment composition.
- Changes in macro zone characteristics on the trip distribution pattern can be tested.

3.4 Review of data requirements and data collection

Figure **3**-**13** indicates the Model Development Process and the data requirements for the different phases in this process. The quality of the data collected for the different phases within the model development process directly influence to output of the model which stresses the importance of collecting accurate and complete information as input to the model.

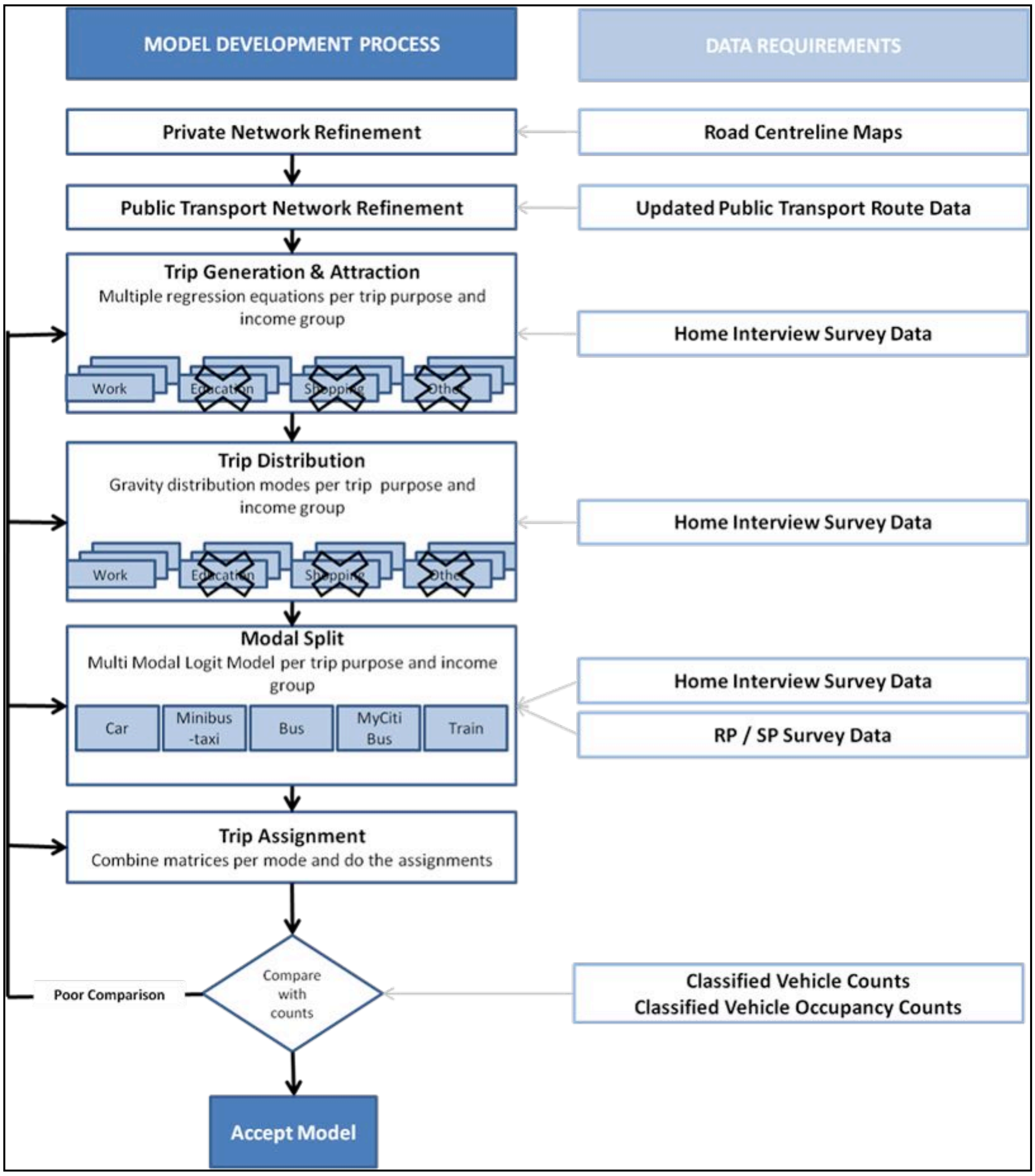


Figure 3-13: 4-step model data requirements

3.4.1 Data Problems

3.4.1.1 Employment Data

Employment data was derived from the Gross Leasable Area's (GLA's) and zoning data provided by the City of Cape Town. It was found that the GLA's had serious deficiencies, some of which are described below:

- The GLA dataset was not complete – large shopping centres and government buildings were excluded from the dataset.
- No distinction was made between occupied and empty buildings in the dataset. It was, therefore, not possible to identified empty buildings.

3.4.1.2 Zoning Data

The zoning data provided supplementary information to the GLA data and made it possible to fill in some of the gaps in the GLA data, but brought along with it its own problems. These related to the difference between zoning and actual land use (since each zone type encompasses a large number of possible land uses), making it impossible to determine the employment accurately from the zoning data.

3.4.1.3 Traffic count data

Various traffic count data sets were received, but only the cordon counts satisfied the requirements for the model validation: that the counts need to be current, per direction and classified by vehicle type. Data that did not fit these criteria were not used for model validation. There was uncertainty regarding the directions of some of the cordon counts stations that could not be solved. Those counts were also omitted from the data used for the validation. This resulted in a very small validation dataset. The count dataset was increased by adding the 2012 non classified counts. These counts were then reduced by 15% (the 15% is the assumed proportion of heavy vehicles, busses and taxi's in the traffic streams) to get the private vehicle volumes.

3.4.1.4 Bus and taxi route data

The bus and taxi route data received were used to update the route data in the model. When the route data was compared to the cordon count data it was found that practically no correlation exist between the route data and the traffic counts, which cast doubt over both the route data and traffic counts.

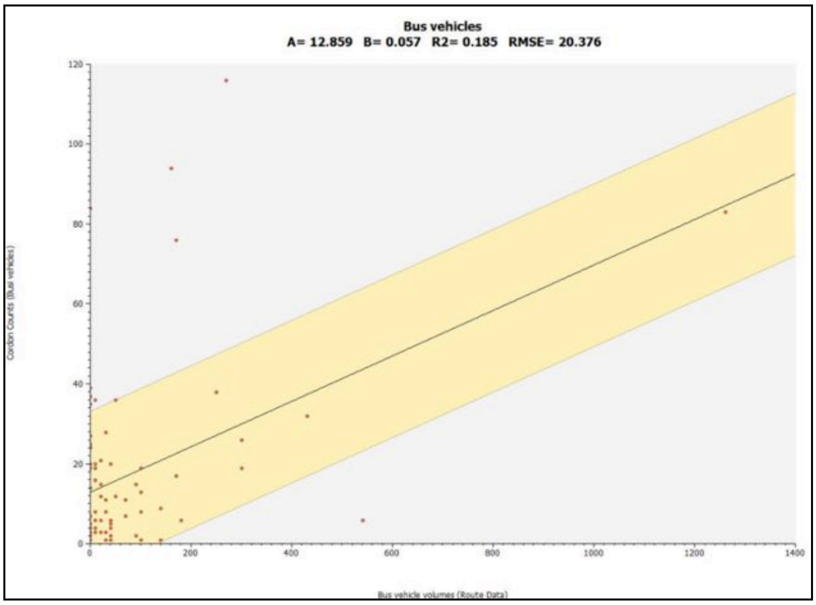


Figure 3-14: Poor correlation between bus volumes and cordon counts

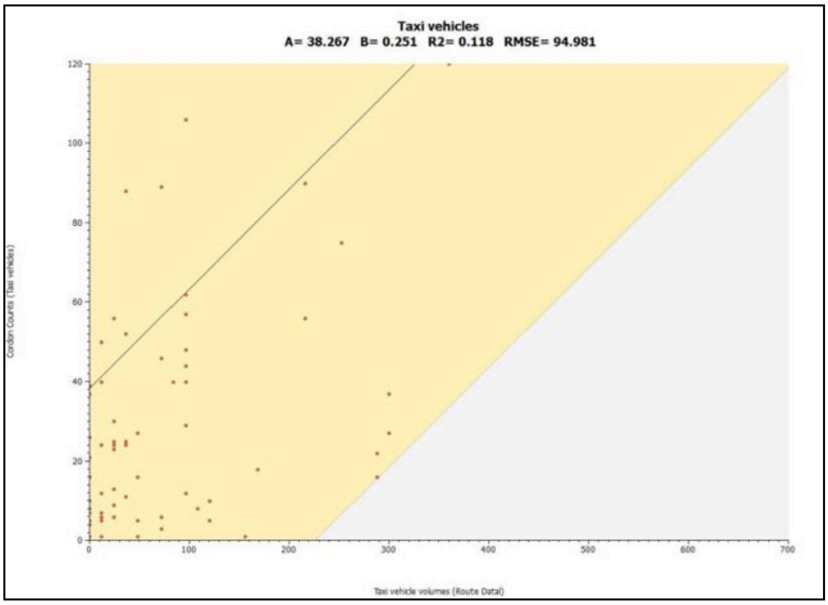


Figure 3-15: Poor correlation between minibus taxi volumes and cordon counts

3.4.1.5 Minibus Taxi boarding data

The minibus taxi boarding data received were also aggregated to macro zone level for validation purposes, but even with this level of aggregation there were areas where the counted number of boarding did not correlate with the population. The absence of formal and informal agreements underlying the boarding counts made it very difficult to interpret the counts. It was thus decided not to use the minibus taxi boarding counts.

3.4.1.6 On-board bus surveys

The on-board bus survey dataset had recorded stop locations that did not align with the road centre line map. These stop locations had to be evaluated individually and manually shifted to align with the centre line map. Other problems identified with the on-board data set were:

- Serious mistakes with regard to the sequence of the recorded stops in terms of time and location were identified.
- Existing GABS routes were not found in the dataset indicating that not all bus routes were surveyed as.
- The stops recorded for some routes did not follow the actual route.
- Some routes had too few recorded stops for evaluation purposes.
- Some routes were recorded with stops on freeways.
- Some routes were recorded with too many stops.
- There was an absence of clear indicators of the actual start and end of each route.

The above mentioned problems made it difficult to determine the actual route alignments. Various iterations of data valuations and corrections had to be implemented to be able to make the data usable for modelling purposes. Even after all these efforts the data was not in an ideal condition and certain doubts with regard to the accuracy still exist. The uncertainty with regard to the bus data was reduced by aggregating the boarding to macro zone level for validation purposes.

3.5 Trip Production and Attraction

Trip generation and attraction is the step in which the total number of person trips produced in each zone and attracted to each zone is calculated. The household travel survey was used to develop this sub model. Trip production and attraction equations were developed using linear regression analysis with the typical equations are as follows:

Trip production: $T_i = a_1X_1 + a_2X_2 + \ldots. + a_nX_n$

Where T_i = number of trip produced at zone i
$a_1..a_n$ = coefficients
$X_1..X_n$ = parameters

Trip Attraction: $T_j = a_1X_1 + a_2X_2 + \ldots. + a_nX_n$

Where T_j = number of trip attracted to zone j
$a_1..a_n$ = coefficients
$X_1..X_n$ = parameters

The trip production and attraction equations were based on the total data set (this includes a percentage of trips outside of the morning peak period). Equations were developed for each trip purpose and income group. The coefficients for the trip production are provided in

Table 3-3 and the trip attraction coefficients in Table **3-4**.

Table 3-3: Trip production coefficients

	TRIP GENERATION										
Purpose	Employed_FullTime	Employed_PartTime	Employed_Self	Unemployed_NotLookingForWork	Unemployed_LookingForWork	Employed_Contract/Seasonal	Pensioner	Student_Tertiary	Student_Scholar	Housewife	<6y
	1	2	3	4	5	6	7	8	9	10	11
	Income Group 1										
Work	0.961	0.827	0.357	0.000	0.000	0.848	0.000	0.000	0.000	0.000	0.000
Education	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.870	0.982	0.000	0.000
Other	0.000	0.000	0.000	0.076	0.021	0.000	0.066	0.000	0.000	-0.093	0.000
	Income Group 2										
Work	0.987	0.974	0.225	0.000	0.000	0.999	0.000	0.000	0.000	0.000	0.000
Education	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.982	0.992	0.000	0.000
Other	0.000	0.000	0.000	0.025	0.038	0.000	0.037	0.000	0.000	-0.017	0.000
	Income Group 3										
Work	0.972	0.847	0.479	0.000	0.000	0.903	0.000	0.000	0.000	0.000	0.000
Education	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.930	0.988	0.000	0.000
Other	0.000	0.000	0.000	0.491	0.093	0.000	0.039	0.000	0.000	0.098	0.000
	Income Group 4										
Work	1.000	0.486	0.319	0.000	0.000	1.218	0.000	0.000	0.000	0.000	0.000
Education	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.971	0.996	0.000	0.000
Other	0.000	0.000	0.000	0.166	0.463	0.000	-0.159	0.000	0.000	0.354	0.000

Table 3-4: Trip attraction coefficients

Purpose	Business-Office	Business-Retail	Industrial-Manufacturing	Industrial-Service	Industrial-Warehouse	Community-Community	Community-Construction	Other-Transport	Other-Parking	Other-Recreation	Secondary-Personel	Secondary - Schoalrs	Tertiary-Personel	Tertiary-Students	Agricultural
	TRIP ATTRACTION														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Income Group 1														
Work	0.878	0.878	0.878	0.878	0.878	0.878	0.878	0.878	0.000	0.878	0.878	0.000	0.878	0.000	0.878
Education	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.968	0.000	0.968	0.000
Other	0.130	0.130	0.130	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Income Group 2														
Work	0.907	0.907	0.907	0.907	0.907	0.907	0.907	0.907	0.000	0.907	0.907	0.000	0.907	0.000	0.907
Education	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.991	0.000	0.991	0.000
Other	0.029	0.029	0.029	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Income Group 3														
Work	0.807	0.807	0.807	0.807	0.807	0.807	0.807	0.807	0.000	0.807	0.807	0.000	0.807	0.000	0.807
Education	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.974	0.000	0.974	0.000
Other	0.060	0.060	0.060	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Income Group 4														
Work	0.599	0.599	0.599	0.599	0.599	0.599	0.599	0.599	0.000	0.599	0.599	0.000	0.599	0.000	0.599
Education	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.988	0.000	0.988	0.000
Other	0.053	0.053	0.053	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

A total of 1 635 113 person trips are generated during the morning peak period. The bulk of the trips (64%) are Home-based Work trips, followed by Home-based Education trips (33%) and Home-based Other trips (2%). A breakdown of the trips is provided in

Table **3-5**.

Table 3-5: 2013 AMPP Person Trips Generated and Attracted

Trip Purpose	Income Group	AMPP Person Trips	Percentage
Home-based Work	Group 1 (low)	256 789	24%
Home-based Work	Group 2 (middle-low)	612 836	58%
Home-based Work	Group 3 (middle-high)	126 250	12%
Home-based Work	Group 4 (high)	56 959	5%
Total		**1 052 835**	**64%**
Home-based Education	Group 1 (low)	184 054	34%
Home-based Education	Group 2 (middle-low)	284 700	52%
Home-based Education	Group 3 (middle-high)	47 676	9%
Home-based Education	Group 4 (high)	26 656	5%
Total		**543 193**	**33%**
Home-based Other	Group 1 (low)	20 221	52%
Home-based Other	Group 2 (middle-low)	11 969	31%
Home-based Other	Group 3 (middle-high)	2 947	8%
Home-based Other	Group 4 (high)	4 056	10%
Total		**39 193**	**2%**
TOTAL		**1 635 113**	**100%**

Trip production and attraction follows the same distribution pattern as the population and employment. Due to the fact that employment and education are more concentrated compared to employment, trip attraction is also more concentrated compared to trip production. The distribution of trip production and attraction for each trip purpose is displayed in Figure **3-16** to Figure **3-21**. The red bars indicate trip production and the blue bars indicate trip attraction.

Figure **3-16** indicates high trip attraction in the Metro South East and Crossroads / Nyanga areas with lower more dispersed trip generation in the other metro areas. This is consistent with Figure **3-18** and Figure **3-20** (representing the trip productions for home-based-education and home-based other) only on a lower scale.

Figure **3-17** indicates high trip attraction in the City centre as well as the Bellville area with very low employment attractions in the Metro South East. Figure **3-19** and Figure **3-21** indicates that education trip attractions and "other" trip attractions are relatively spread across the metro.

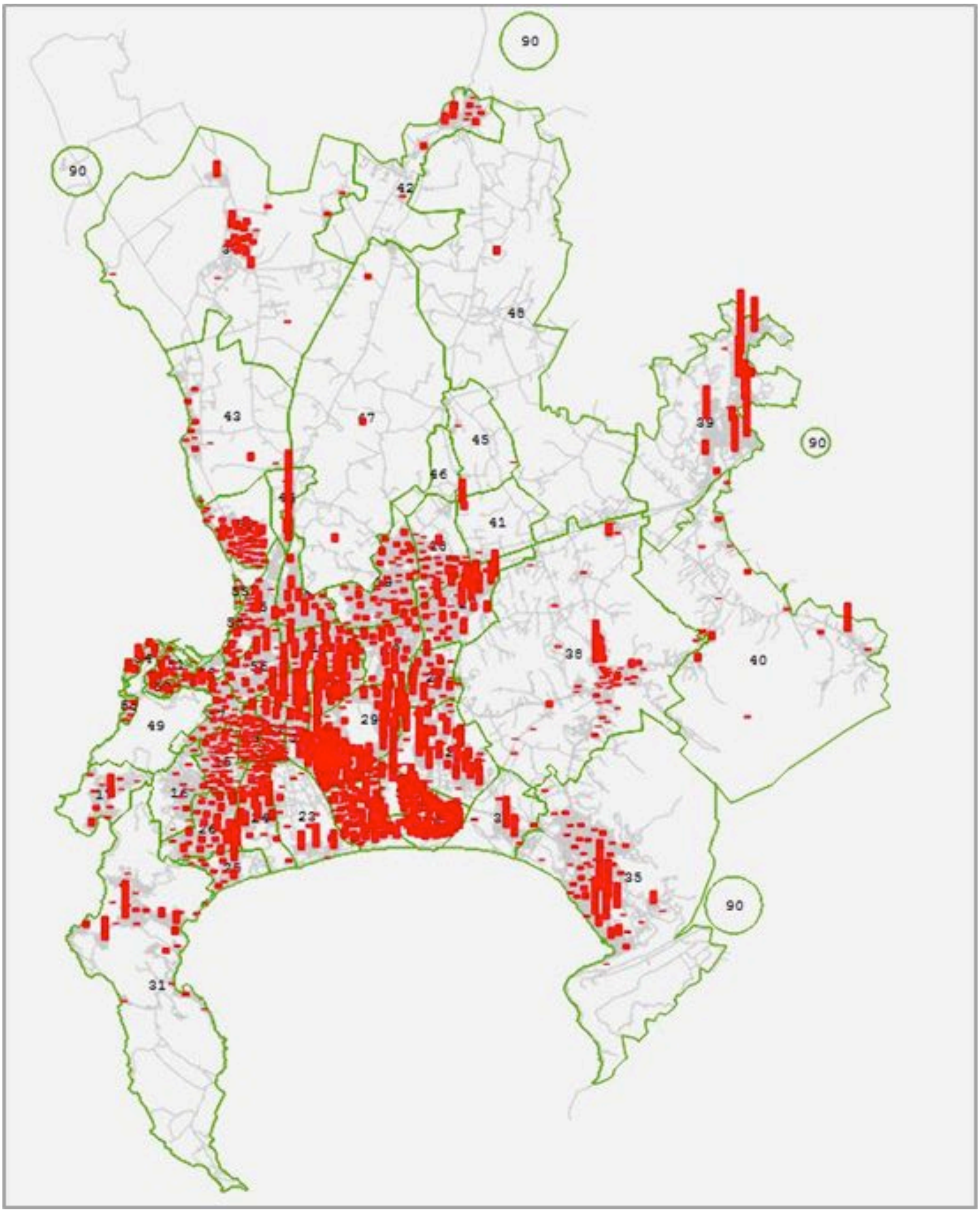


Figure 3-16: 2013 Home-based Work Trip production (AMPP distribution)

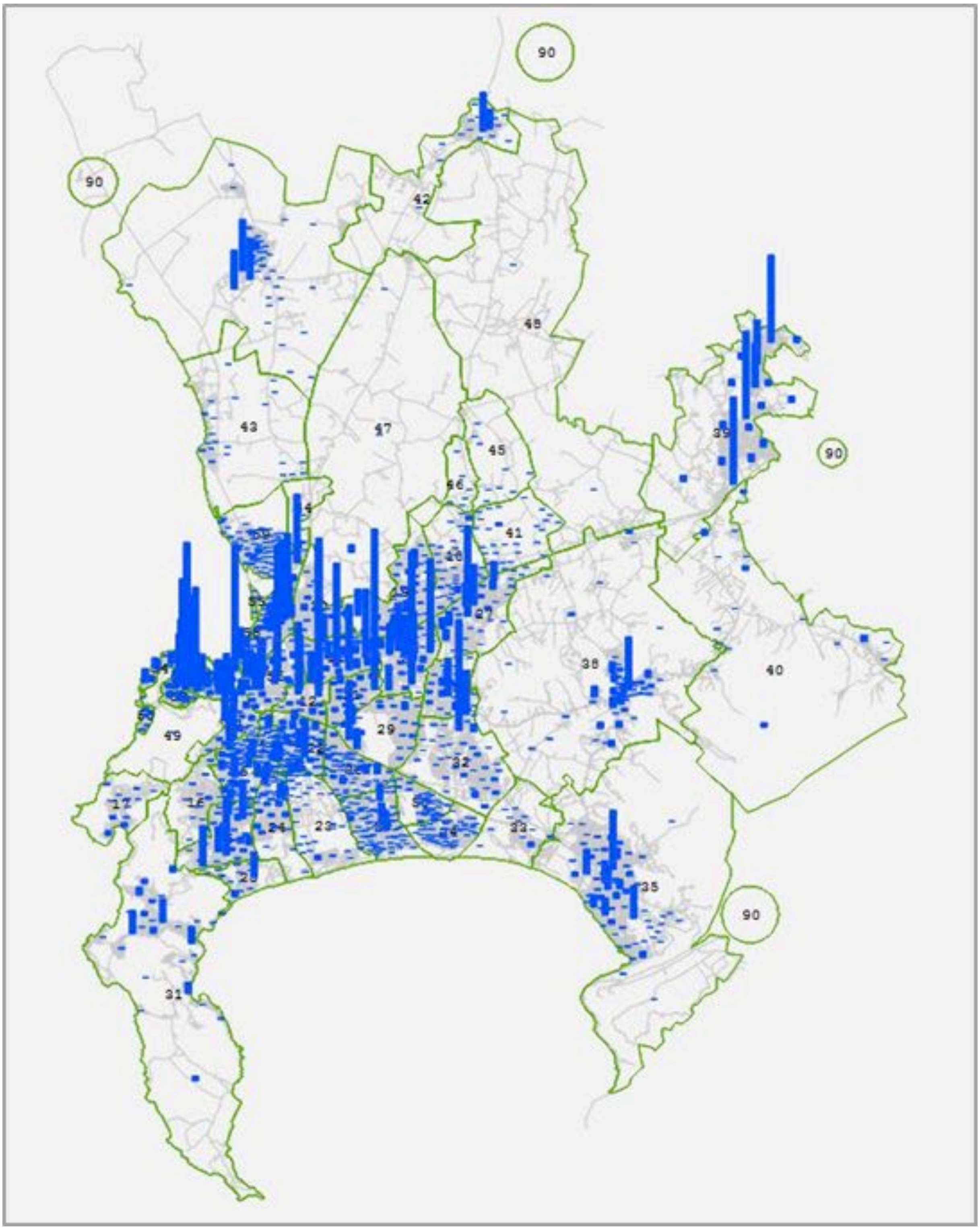


Figure 3-17: 2013 Home-based Work Trip Attraction (AMPP distribution)

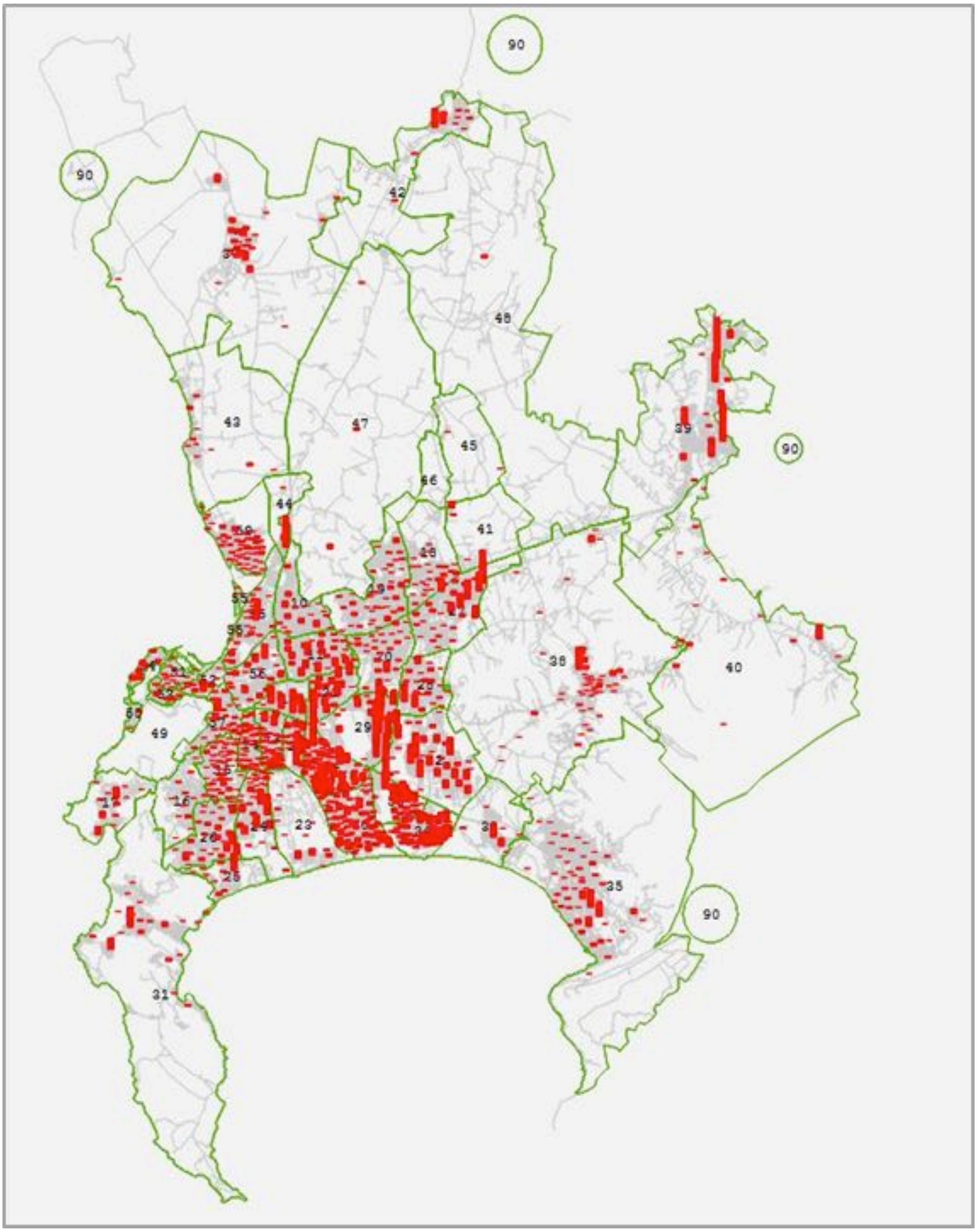


Figure 3-18: 2013 Home-based Education Trip Production (AMPP distribution)

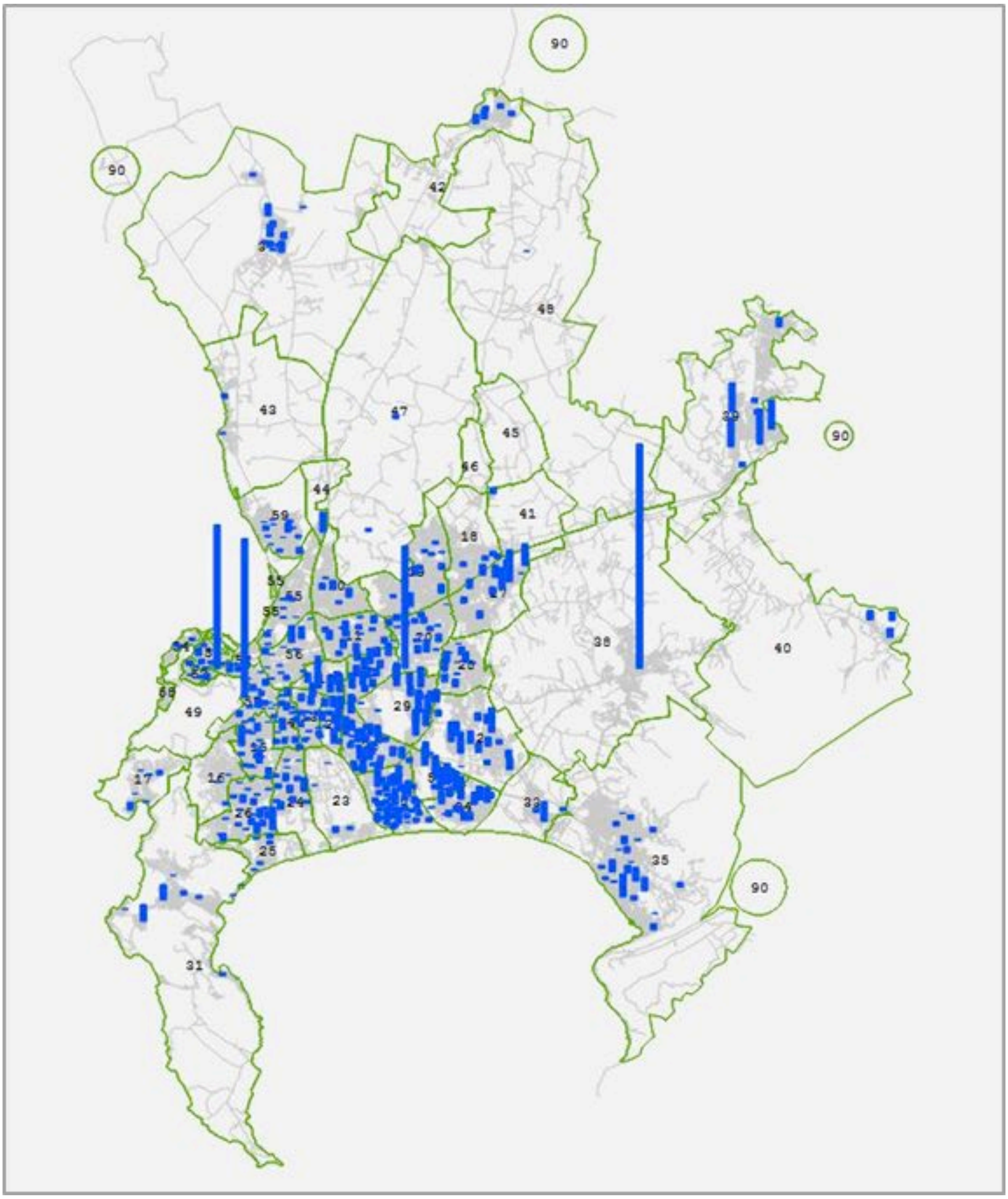


Figure 3-19: 2013 Home-based Education Trip Attraction (AMPP distribution)

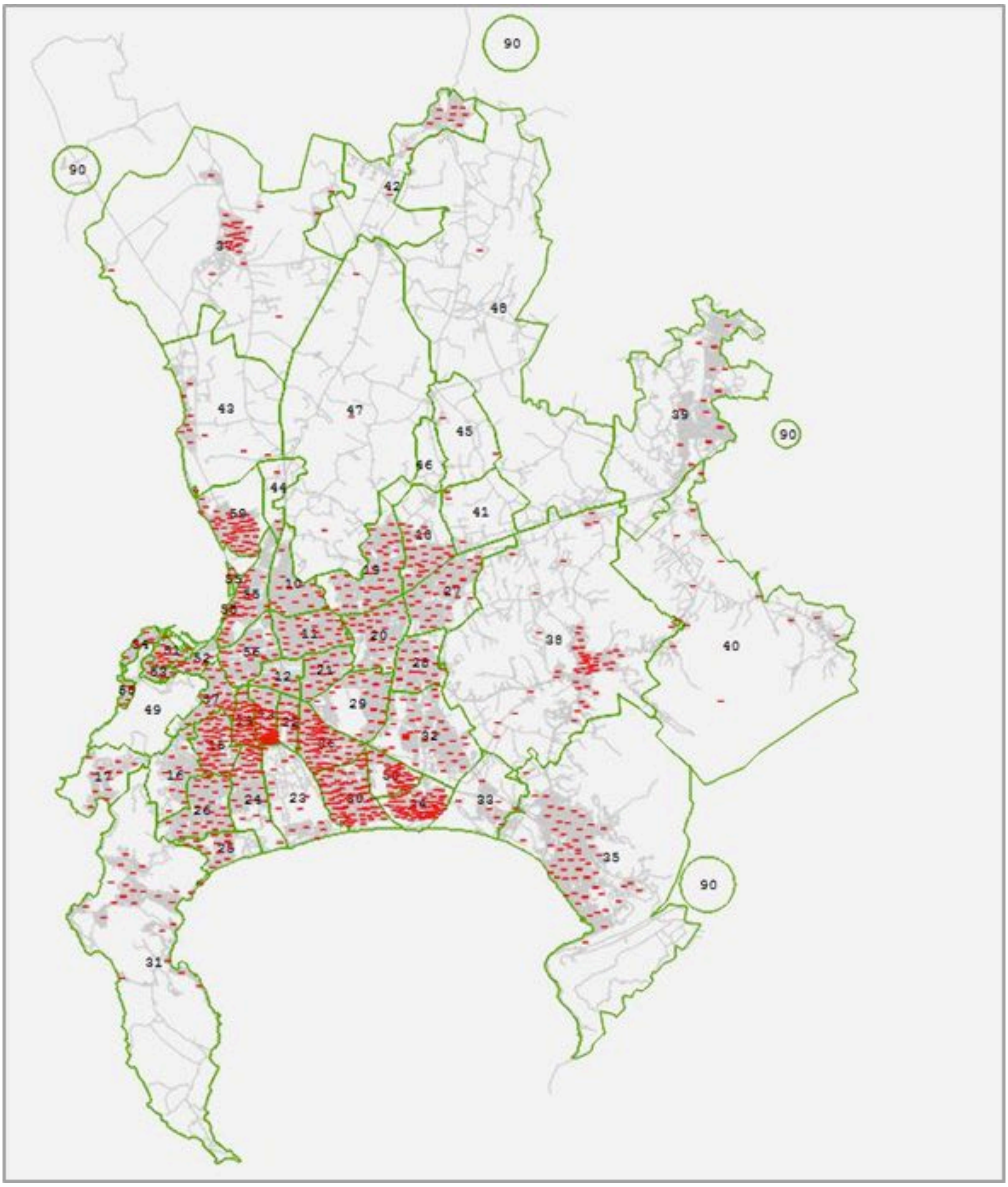


Figure 3-20: 2013 Home-based Other Trip Production (AMPP distribution)

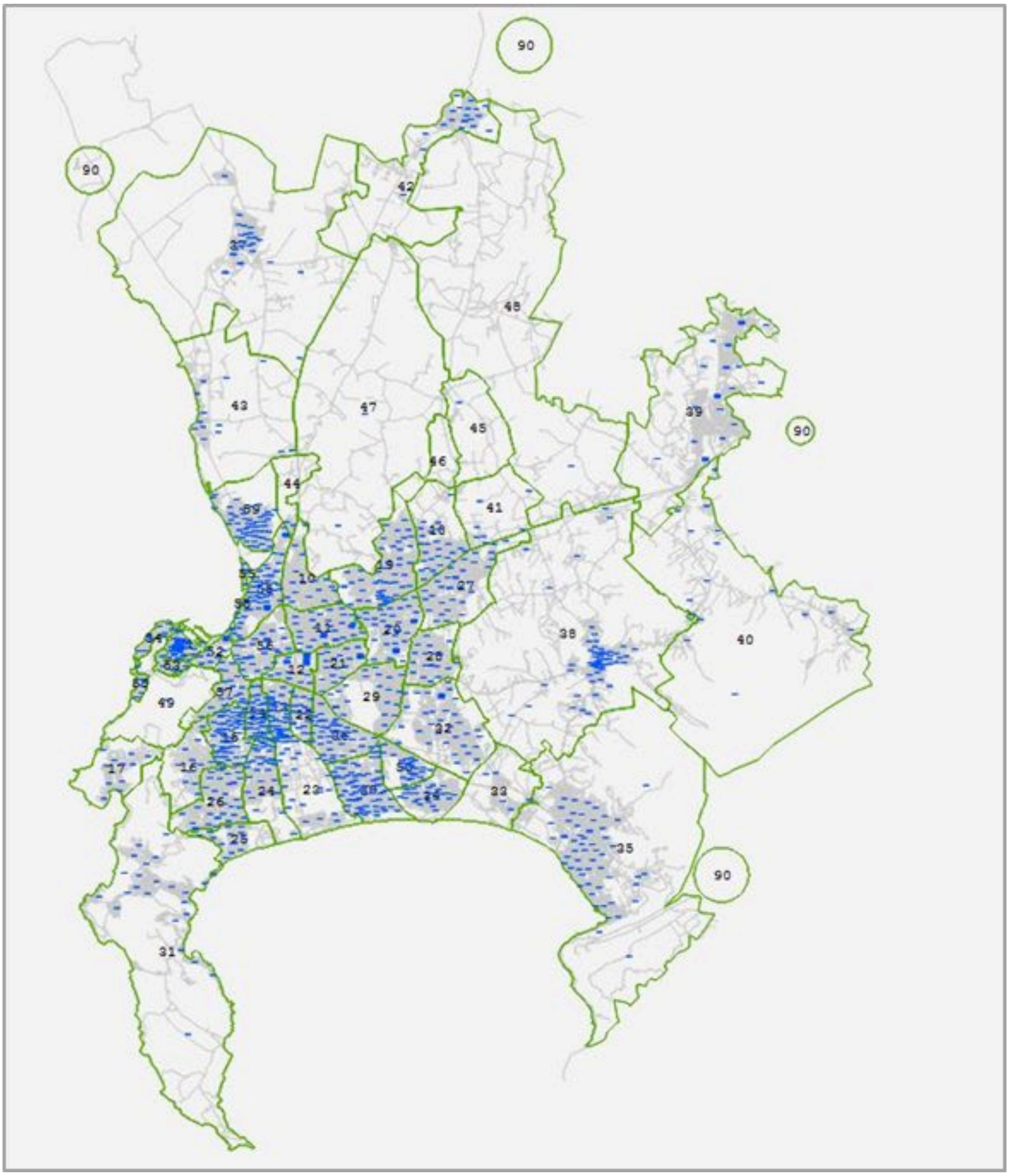


Figure 3-21: 2013 Home-based Other Trip Attraction (AMPP distribution)

3.6 Trip Distribution

Trip distribution is the step in which the produced and attracted trips are distributed between each origin-destination pair and is done for the morning peak period. Intra zonal trips were not distributed and are based on proportions derived from the household survey data and were calculated before the trip distribution was done. The results of the intra zonal trip calculations are summarized in Table 3-6. The average percentage intra zonal trips for Home-based Work (HBW) trips are 6%, for Home-based Education (HBE) the average percentage is 30% and for Home-based other (HBO) the average percentage is 11%. Percentage intra zonal trips will be lower compared to previous models as a result of the smaller zones, especially for the Lansdowne-Wetton Corridor area.

Table 3-6: 2013 AMPP Intra Zonal Person Trips

Trip Purpose	Income Group	AMPP Person Trips	AMPP intra zonal Person Trips	Percentage
HBW	Group 1 (low)	256 789	14 629	6%
HBW	Group 2 (middle-low)	612 836	38 978	6%
HBW	Group 3 (middle-	126 250	6 204	5%
HBW	Group 4 (high)	56 959	2 214	4%
Total		**1 052 835**	**62 025**	**6%**
HBE	Group 1 (low)	184 054	54 616	30%
HBE	Group 2 (middle-low)	284 700	94 866	33%
HBE	Group 3 (middle-	47 676	10 620	22%
HBE	Group 4 (high)	26 656	4 605	17%
Total		**543 193**	**164 707**	**30%**
HBO	Group 1 (low)	20 221	2 158	11%
HBO	Group 2 (middle-low)	11 969	1 689	14%
HBO	Group 3 (middle-	2 947	391	13%
HBO	Group 4 (high)	4 056	0	0%
Total		**39 193**	**4 238**	**11%**

The gravity trip distribution model is used which has the general formulation:

$T_{ij} = \propto O_i D_j f(c_{ij})$

Where T_{ij} = Trips from zone i to zone j
A = constant
O_i = Total trips generated at zone i
D_i = Total trips attracted to zone j
$F(c_{ij})$ = deterrence function

Trip distribution is done by trip purpose, income group and macro zone to cater for the significant differences in trip distribution patterns across the modelled area.

Deterrence functions are used to make sure that the distribution of trips produced by the gravity model matches what is reported during the household survey. The deterrence functions have the following form:

$$f(c_{ij}) = c_{ij}^{\alpha} exp^{(-\beta c_{ij})}$$

Where $f(c_{ij})$ = deterrence between zones i and j
c_{ij} = freeflow travel time between zones i and j
α = power
β = coefficient

Deterrence functions were calibrated for each of the categories mentioned (resulting in 588 deterrence functions). An example of how the deterrence functions differ between different macro zones is shown in Figure **3**-**22**.

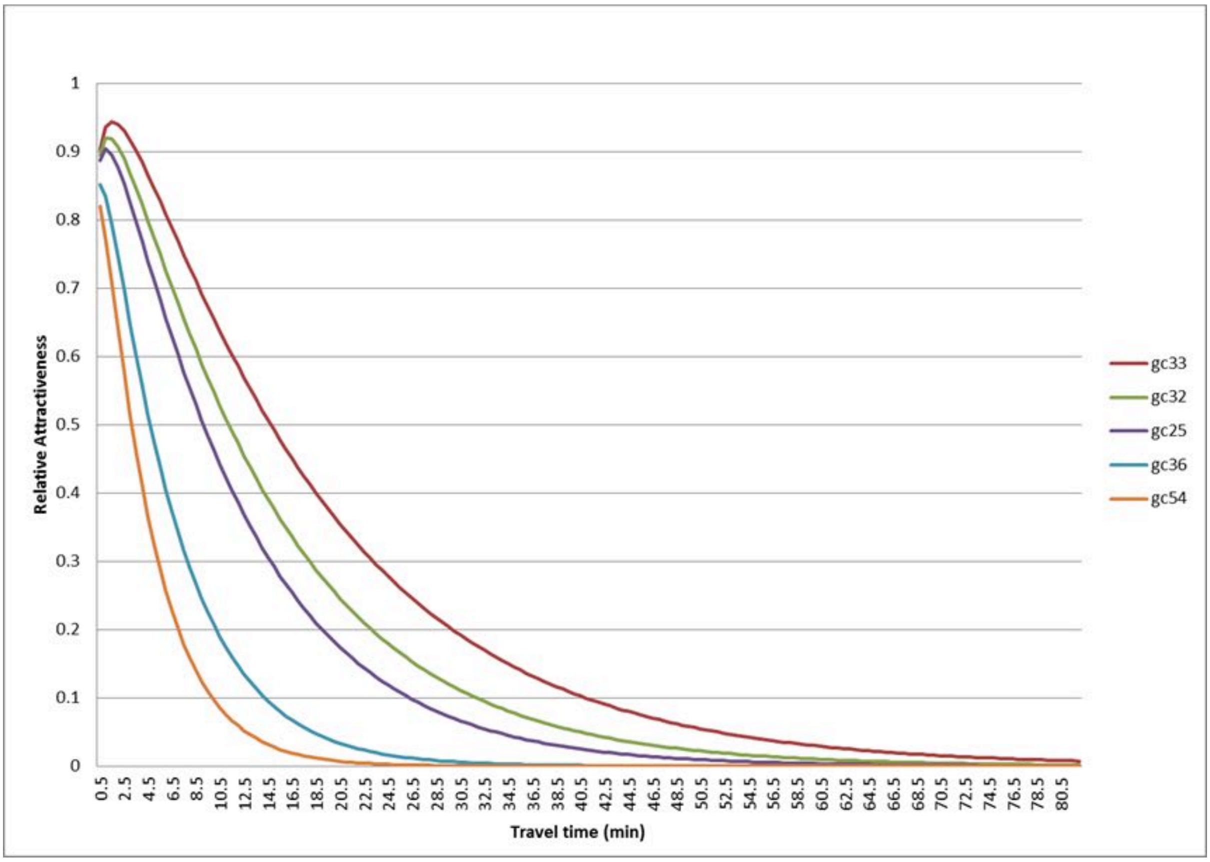


Figure 3-22: Deterrence functions for selected macro zones

The macro zones shown in are Macassar (gc33), Blue Downs (gc32), Muizenberg (gc25), Cross Roads (gc36) and Sea Point (gs54).

The desire lines for the three trip purposes are displayed in Figure **3**-**23**, Figure **3**-**24** and Figure **3**-**25**. The desire lines show the number of trips between macro zones. The width of the lines shows the number of trips while the size of the dots shows the number of intra zonal trips. Desire lines with less than 1000 trips were for Home-based Work and Home-based Education trips are not shown, and desire lines with less than 200 trips for Home-based Other trips are not shown.

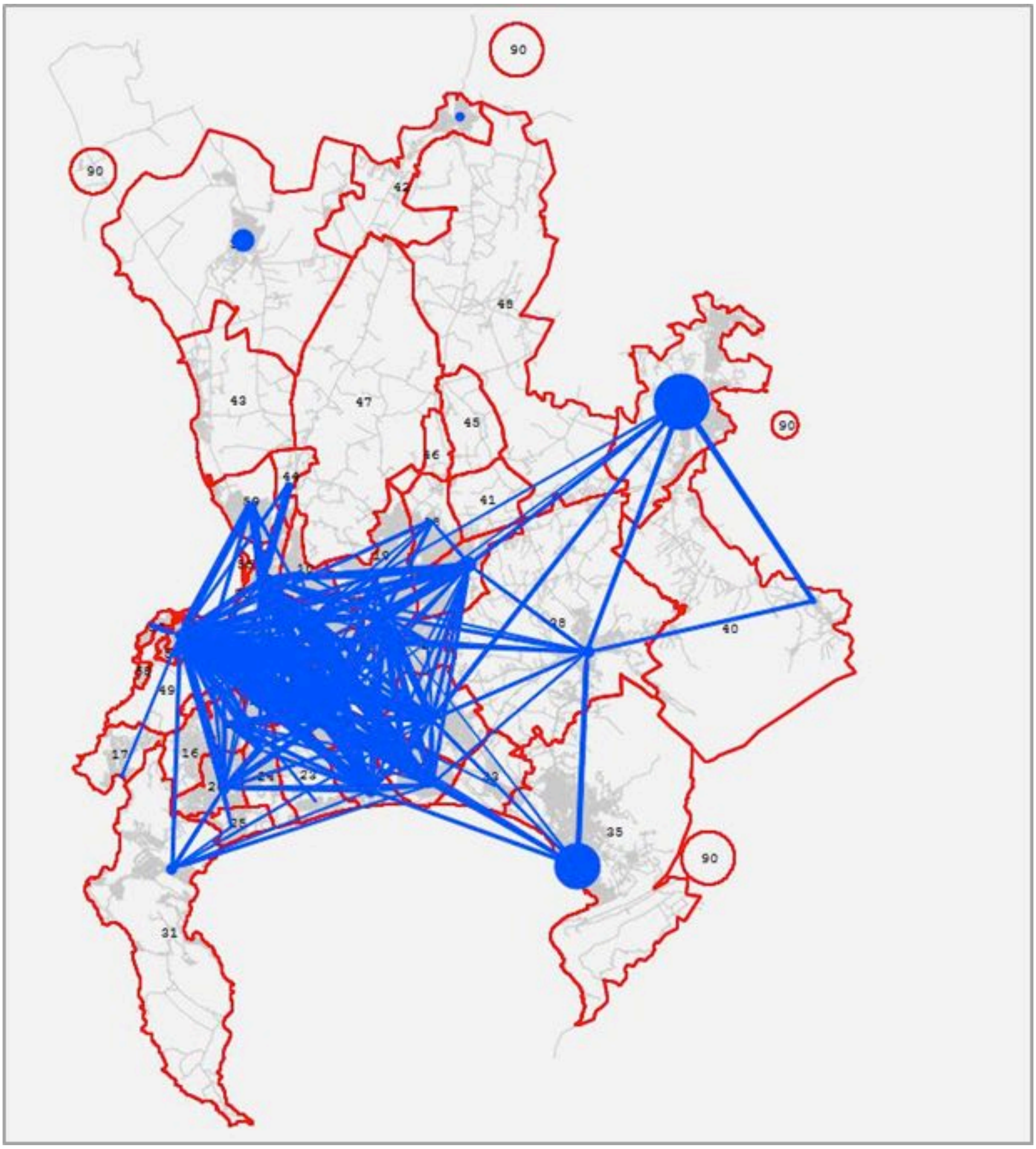


Figure 3-23: 2013 Home-based Work Desire Lines (AMPP)

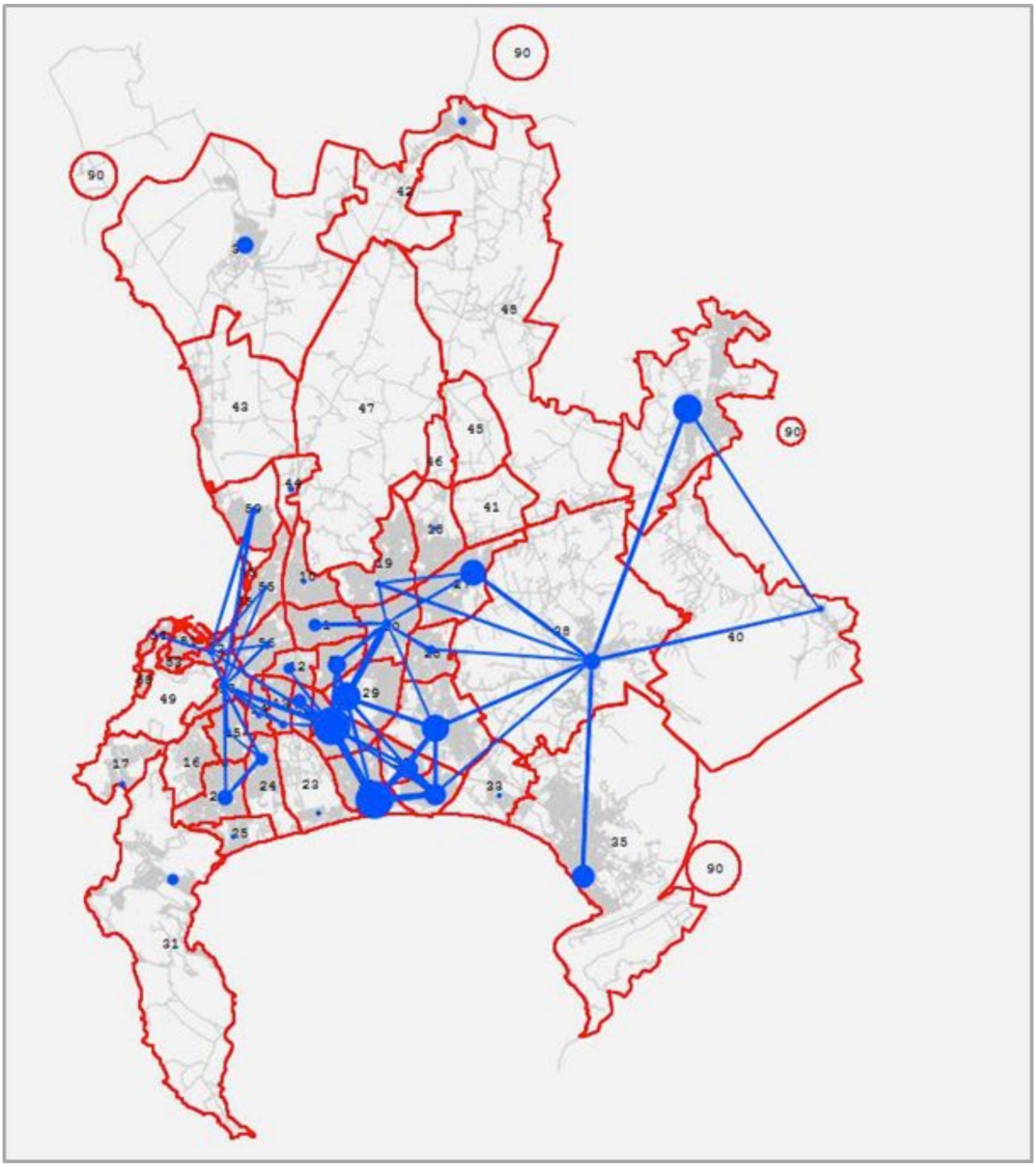


Figure 3-24: 2013 Home-based Education Desire Lines (AMPP)

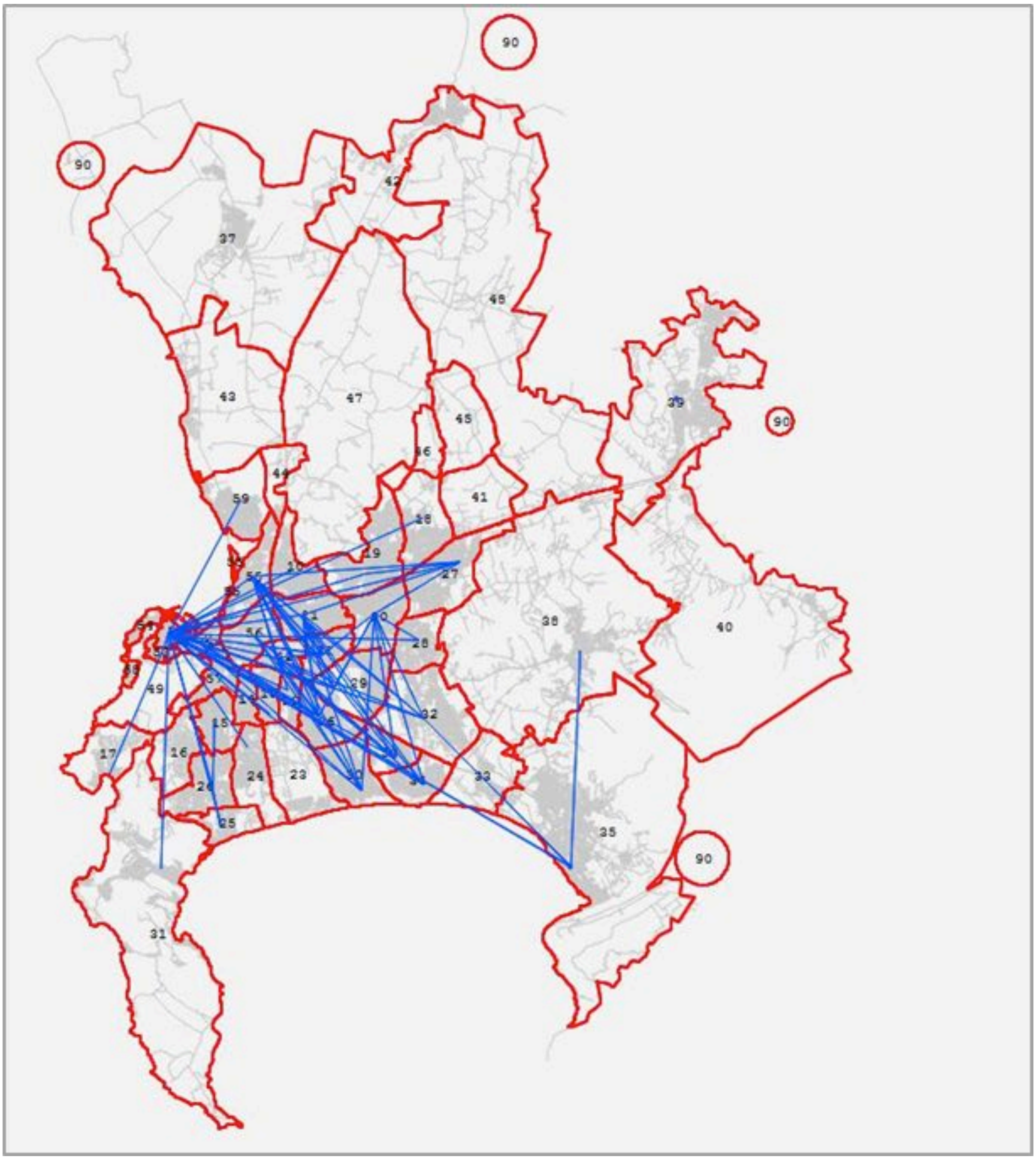


Figure 3-25: 2013 Home-based Other Desire Lines (AMPP)

Figure 3-26 to Figure **3**-**29** indicate the origin to destination desire lines for all morning peak period (AMPP) person trips in 2013 base year. Figure **3**-**30** to Figure **3**-**33** indicate the origin to destination desire lines for all public transport morning peak period (AMPP) person trips in 2013 base year.

Figure 3-26: 2013 AM Peak Period Origin-Destination movement (All person trips): Demand 10 000 - 20 000

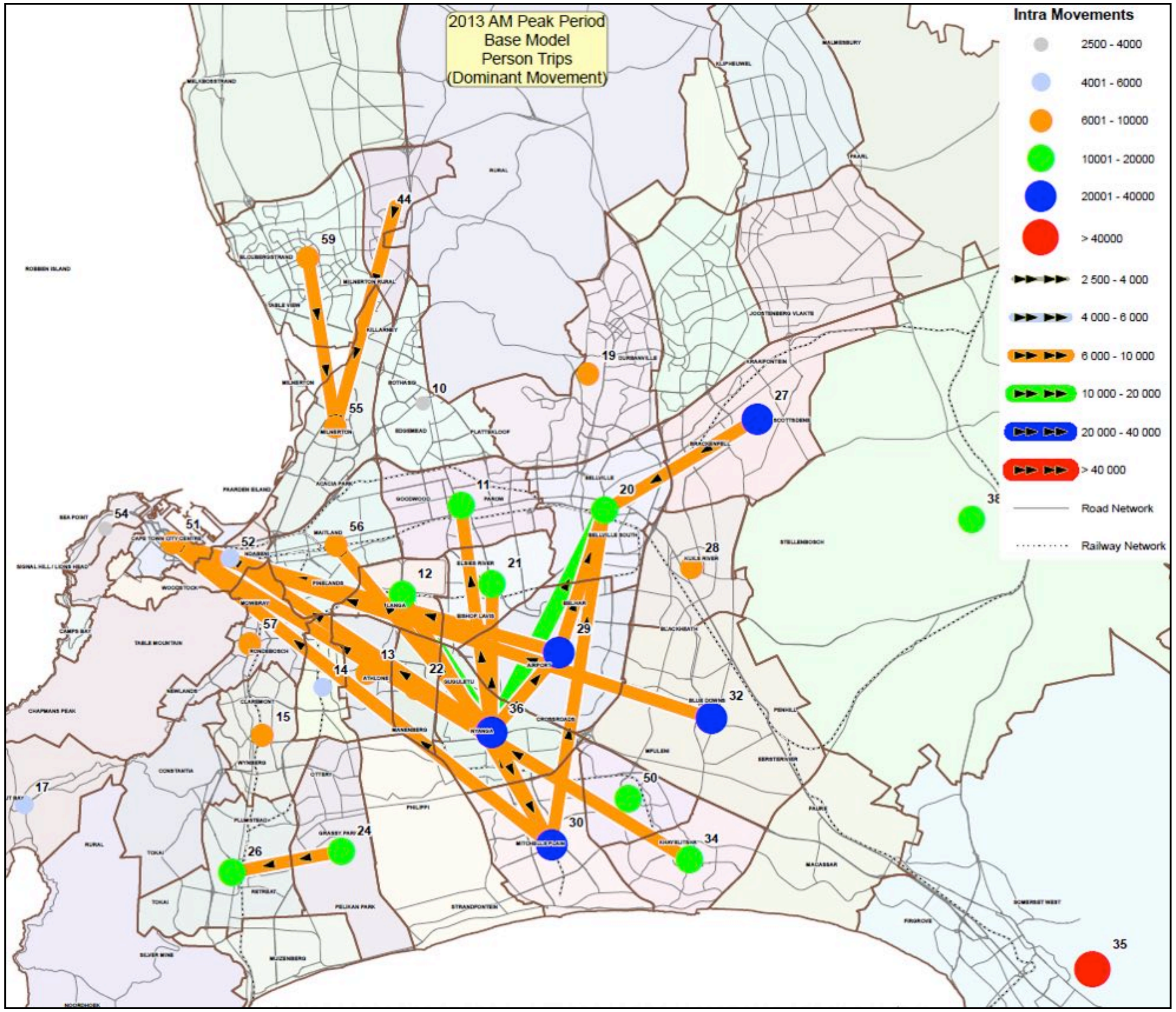


Figure 3-27: 2013 AM Peak Period Origin-Destination movement (All person trips): Demand 6 000 - 10 000

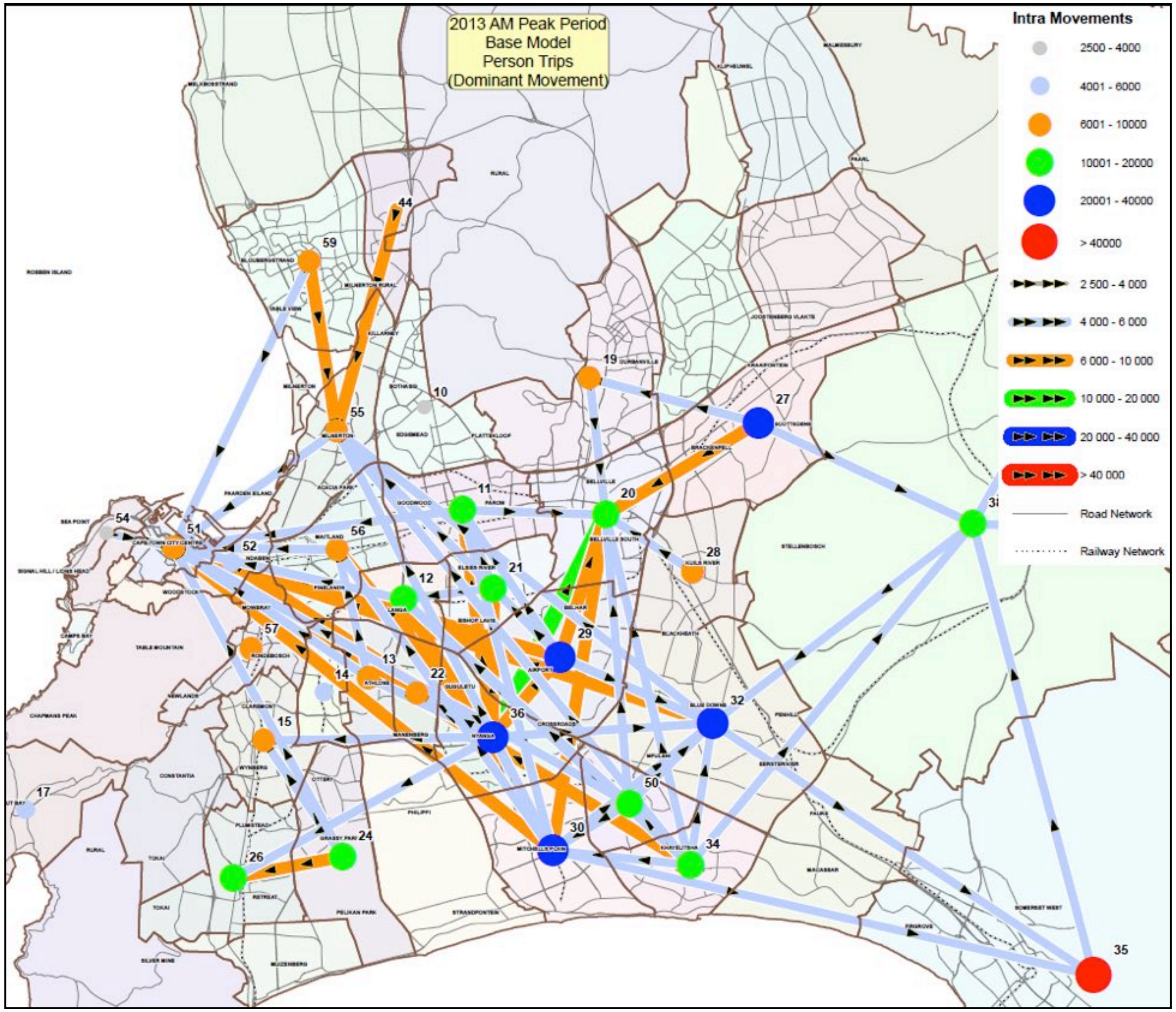


Figure 3-28:2013 AM Peak Period Origin-Destination movement (All person trips): Demand 4 000 – 6 000

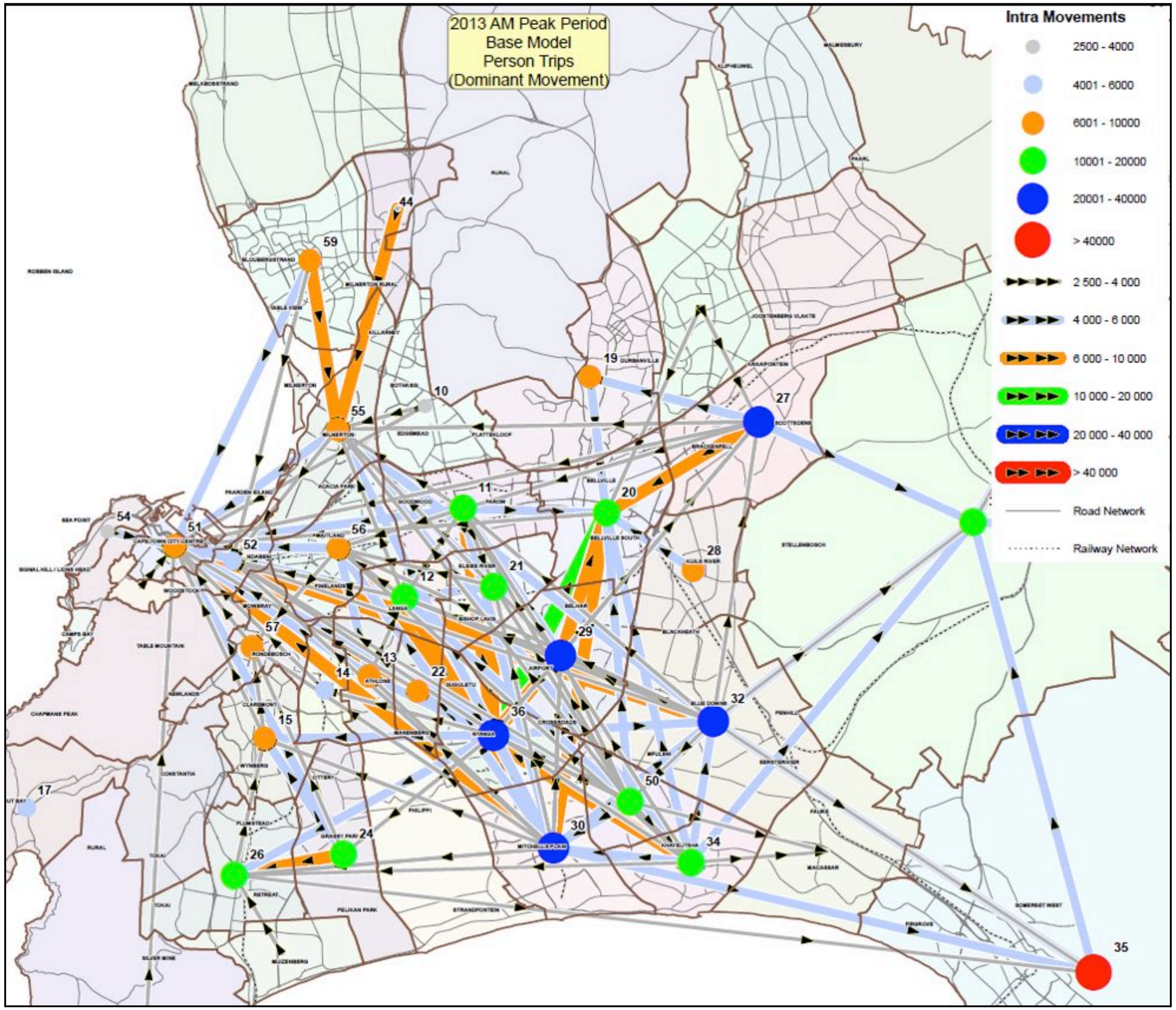


Figure 3-29: 2013 AM Peak Period Origin-Destination movement (All person trips): Demand 2500 - 4 000

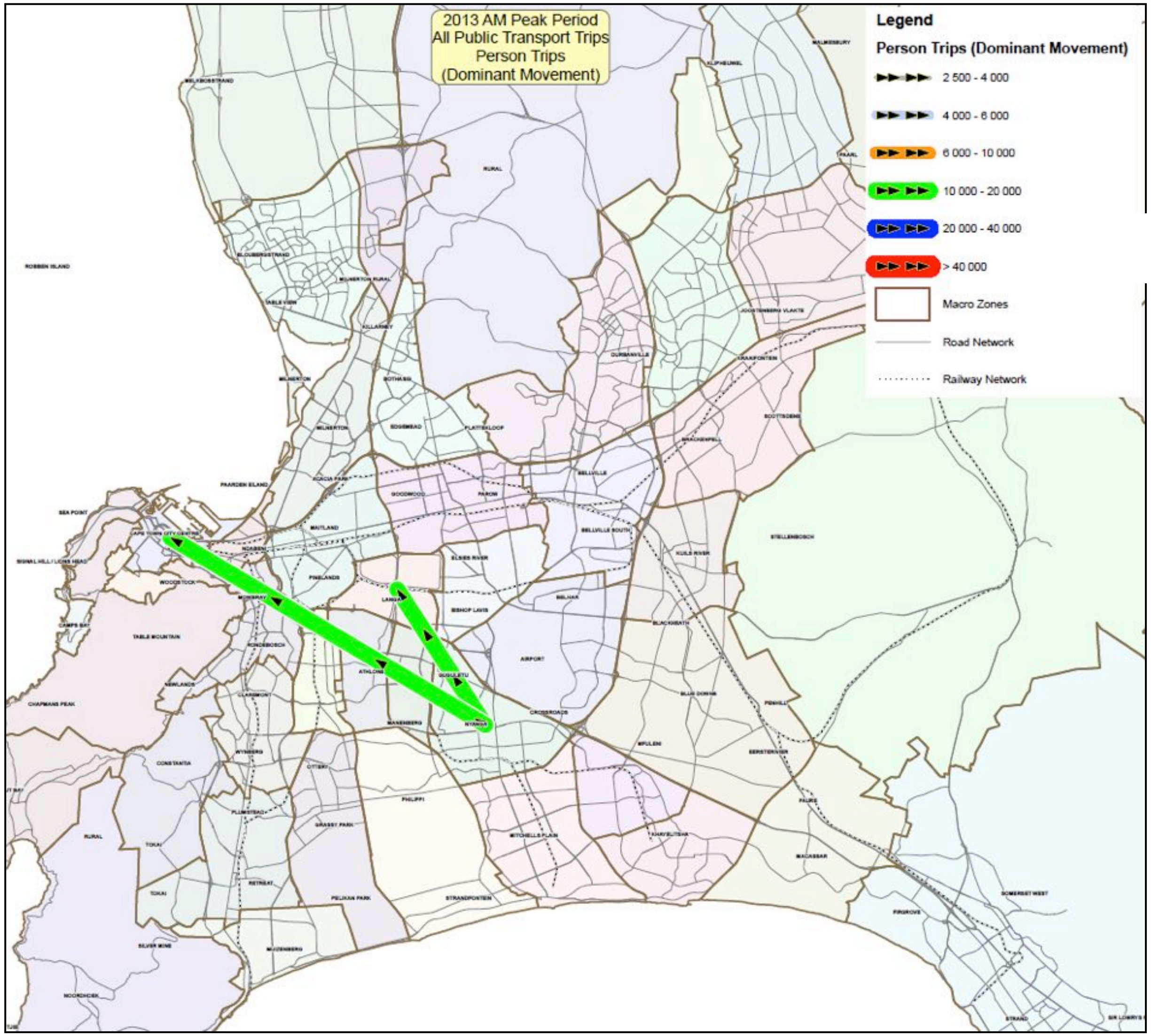


Figure 3-30: 2013 AM Peak Period Origin-Destination movement (Public Transport person trips): Demand 10 000 - 20 000

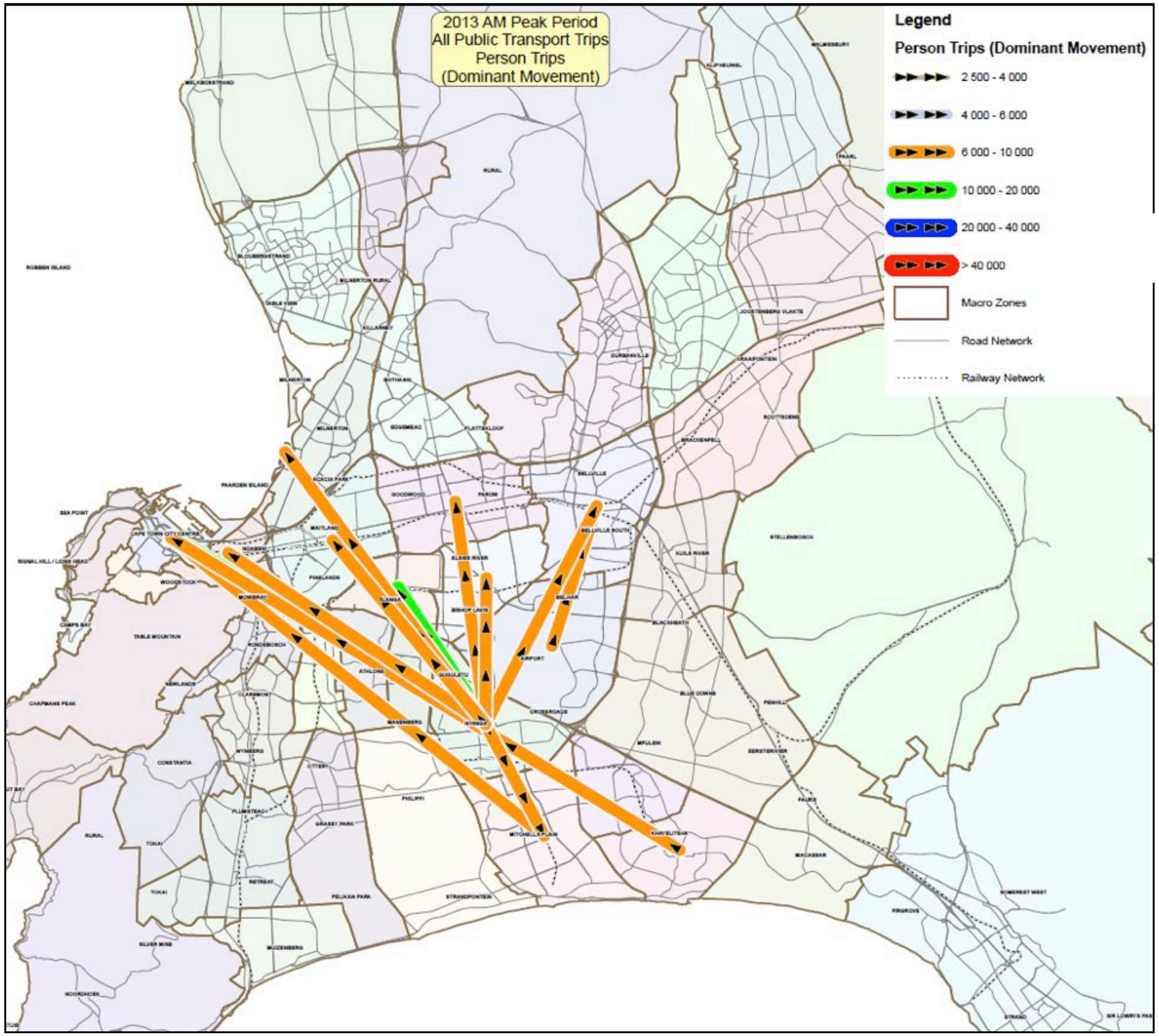


Figure 3-31: 2013 AM Peak Period Origin-Destination movement (Public Transport person trips): Demand 6 000 - 10 000

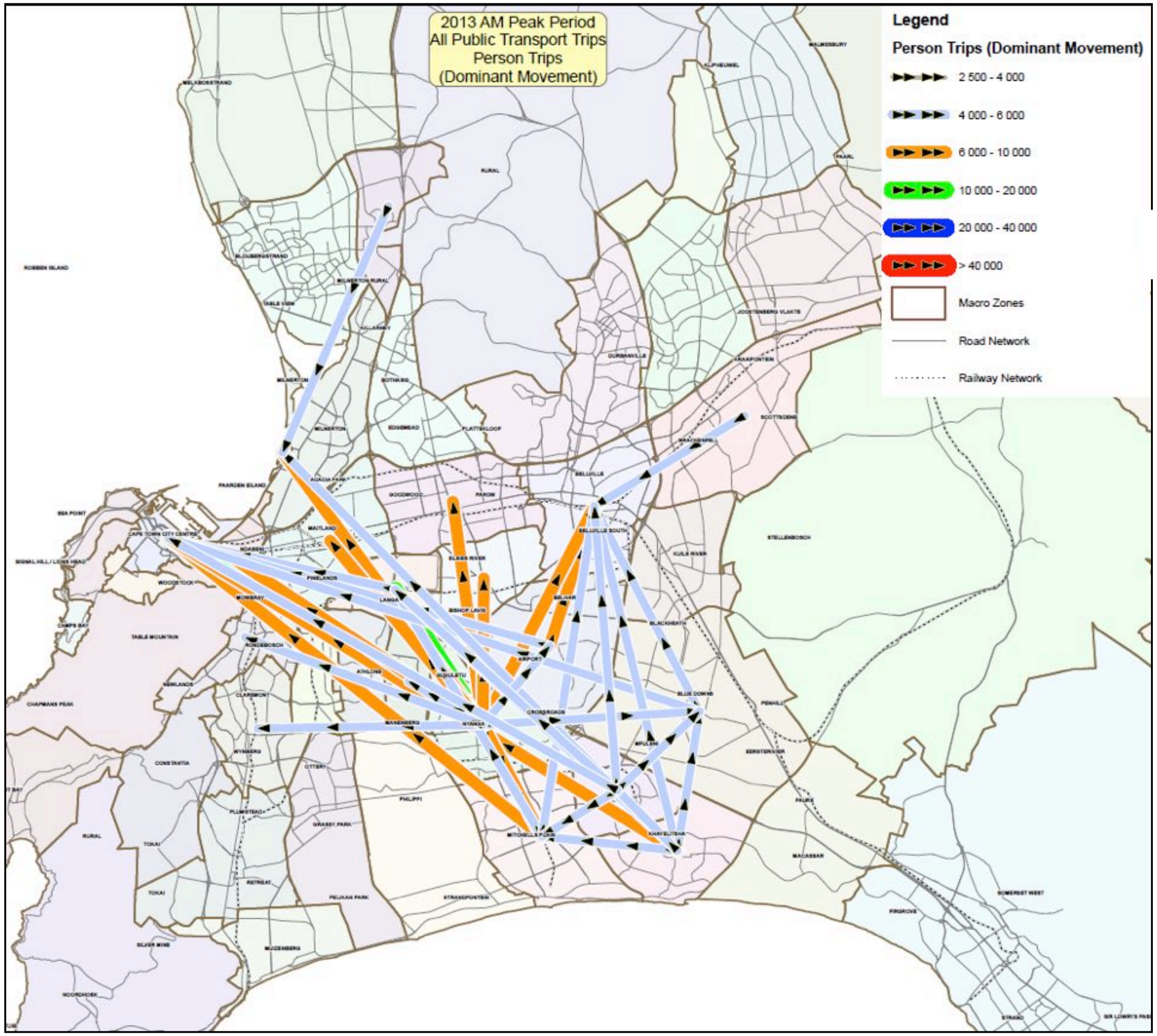


Figure 3-32: 2013 AM Peak Period Origin-Destination movement (Public Transport person trips): Demand 4 000 - 6 000

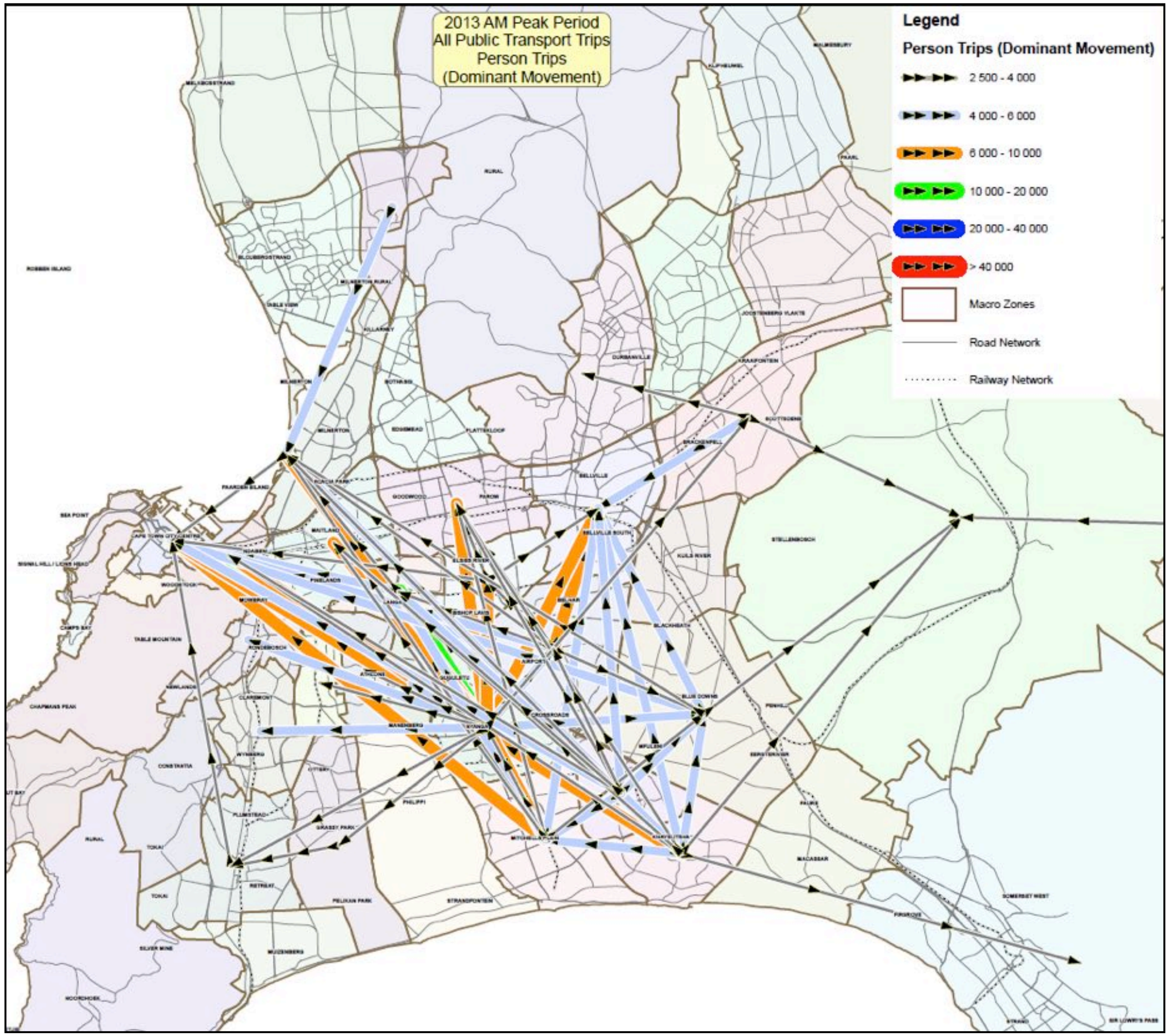


Figure 3-33: 2013 AM Peak Period Origin-Destination movement (Public Transport person trips): Demand 2 500 - 4 000

3.7 Modal Split

The Transport demand model (EMME/4 software) forecasts the demand according to the traditional 4-Step Process with the modal Split analysis as Step 3. This step estimates the modal choice of users by estimating the probability of a transport user choosing a certain mode of transport.

Two data sources were used to estimate the modal split model:

- 2013 Household Travel survey
- 2013 Stated Preference survey

The household travel survey identified the user's current modal choice given determinants such as their current travel time, mode alternatives, comfort, vehicle ownership etc. This dataset was used, in particular, to determine the split between non-motorised transport (NMT) and motorised transport (Private- and public transport).

The stated preference survey was used to determine the modal split by asking the respondent to make a choice between two or more "hypothetical" transport alternatives given certain attributes (refer to the data collection plan, 2013). The respondent, thus, makes a trade-off between two or more modes given specific in-vehicle time, cost, waiting time and the number of transfers for each alternative. This then predicts which mode the respondent *would* have chosen *were* a certain mode (such as BRT) available.

The modal split derived in this way is applied to the morning peak period inter zonal person trips (intra zonal person trips are excluded) by means of the multimodal-split model. Utility functions derived from the Stated Preference survey data are applied for each trip purpose and income group and have the form:

$$U_{11} = c_{111}\, TravelTime + c_{112}\, WalkTime + c_{113}\, WaitTime + c_{114}\, Transfers + c_{115}\, Cost + C$$

Where U_{11} = Utility function for trip purpose 1, Income group 1
c_{111} = Coefficient 1 for trip purpose 1, Income group 1
c_{112} = Coefficient 2 for trip purpose 1, Income group 1
c_{113} = Coefficient 3 for trip purpose 1, Income group 1
c_{114} = Coefficient 4 for trip purpose 1, Income group 1
c_{115} = Coefficient 5 for trip purpose 1, Income group 1
Travel Time = Travel time (min)
Walk Time = Walk time (min)
Wait Time = Wait time (min)
Transfer = Number of transfers
Cost = Ticket Fare (ZAR)
C = Constant

A hierarchical structure is followed in the modal split consisting of the following three levels (as depicted in Figure **3**-**34**):

- Level 1: Split between Non-Motorised and motorised modes only to distances shorter than 9 kilometres, based on distance only.
- Level 2: Split between existing motorised modes (private vehicles, taxi, bus, MyCiTi and rail)
- Level 3: Split between available motorised modes and future MyCiTi.

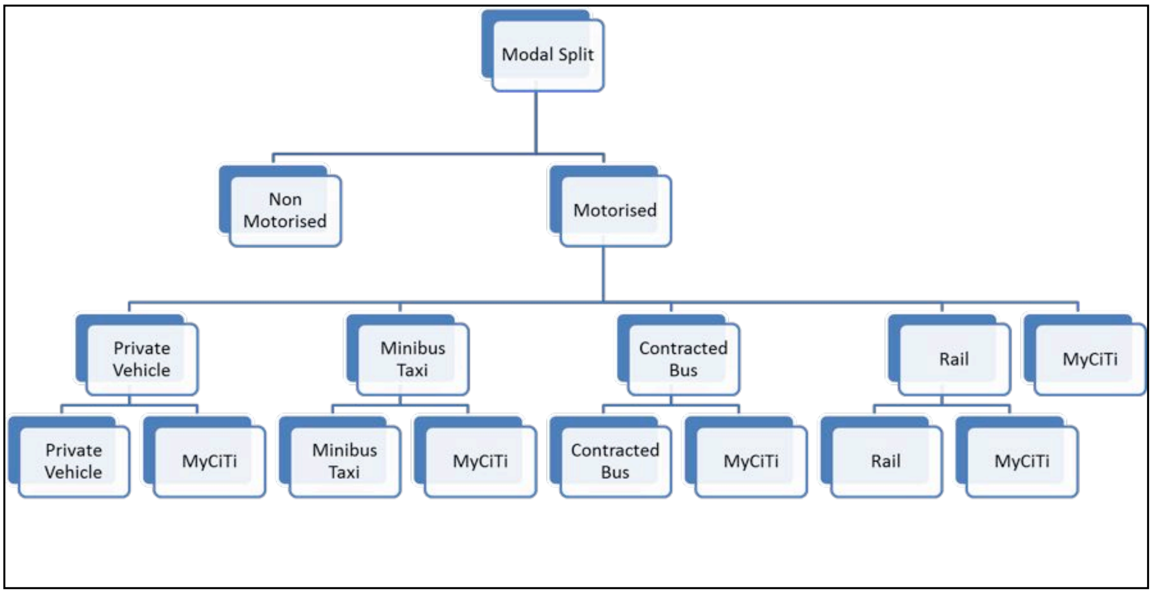


Figure 3-34: Modal Split Structure

These utility functions are included in the EMME/4 model. This makes the model more dynamic than the previous 2010 transport demand model. The new model takes into account the availability of the mode and is sensitive to changes in travel time, the cost of public transport and fuel prices, accessibility, reliability and the number of transfers for each trip. Changes to the different IPTN alternatives (different route alignments, travel characteristics, transfer opportunities, modes etc.) will, thus, affect the modal split and more accurately forecast the preference of users using public transport in the future.

3.7.1 Modal Split Results

The modal split for the AMPP for 2013 (for inter zonal trips) is provided in Table **3-7** while a graphical representation of the modal split proportions is provided in Figure **3-35**.
The first observation is that private transport is the preferred mode and that the choice of this mode is mostly dependent on income. The proportion of persons choosing the private vehicle is lowest in the low income group (but still significant) and this proportion increase as the income increases – for all trip purposes. The private / public transport split is 58% / 42% (when walk trips are excluded).

The percentage of walk trips is 8%, which is significant. The highest proportion walk trips are found in the Home-based Education low income group (31%) followed by the middle-low income group (18%).

Table 3-7: 2013 AMPP Modal Split Results

Category	Walk	Private Vehicle	Minibus Taxi	Contracted Bus	MyCiTi	Rail
HBW (low income)	10 820	82 372	66 555	28 694	115	53 223
HBW (middle-low income)	21 768	321 841	84 105	56 733	679	87 837
HBW (middle-high income)	1 500	102 362	5 707	4 173	244	5 916
HBW (high income)	637	49 804	1 644	613	184	1 822
HBE (low income)	39 661	34 415	19 934	21 467	9	13 896
HBE (middle-low income)	33 621	84 778	26 308	30 541	264	14 270
HBE (middle-high income)	1 630	29 408	1 983	3 119	68	842
HBE (high income)	242	19 189	729	1 248	57	583
HBO (low income)	867	6 659	5 374	1 039	2	4 099
HBO (middle-low income)	525	5 490	1 569	1 113	41	1 529
HBO (middle-high income)	65	2 486	0	0	0	0
HBO (high income)	72	3 980	0	0	0	0
Total	**111 408**	**742 785**	**213 907**	**148 741**	**1 664**	**184 015**

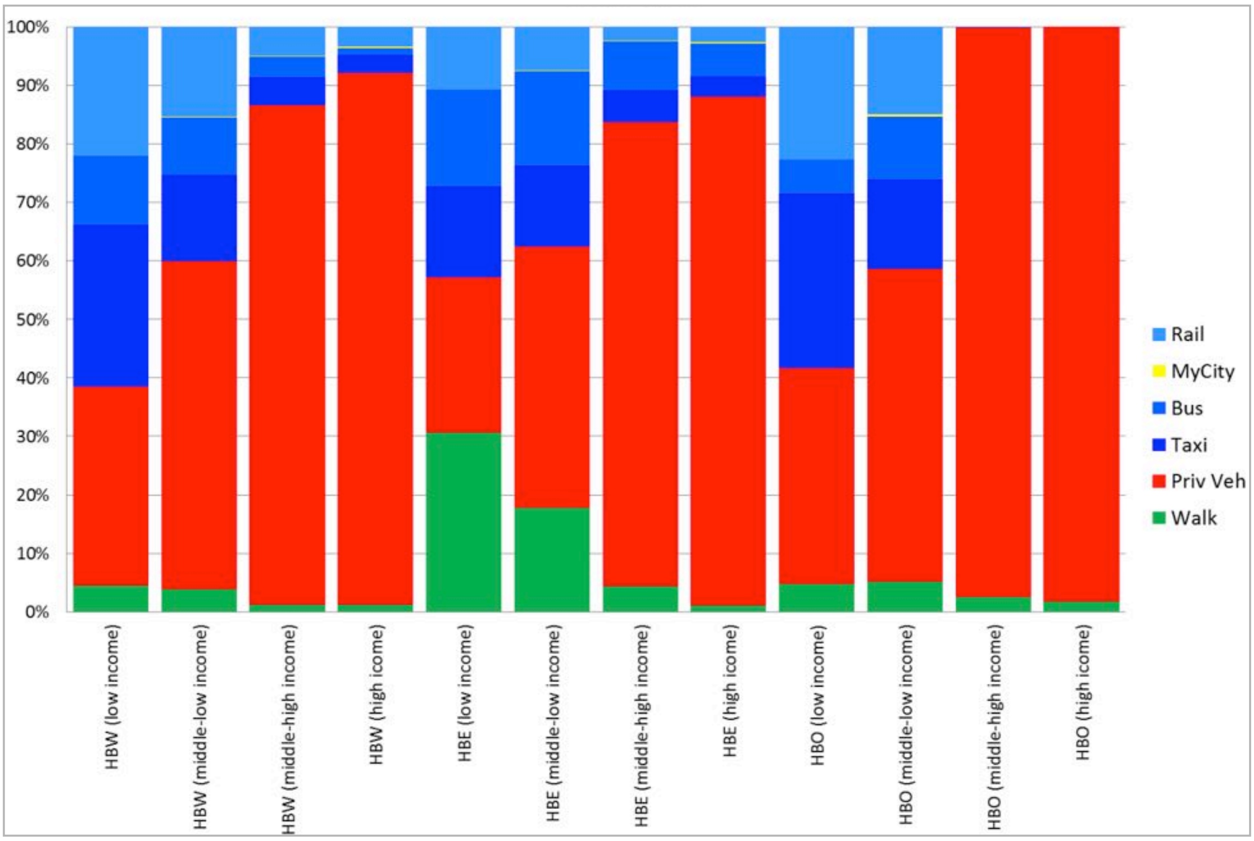


Figure 3-35: 2013 AMPP Modal Split proportions

3.8 Calibration of the model

Model calibration was part of the model development process and was based on various data sources. These data sources were used to develop each step of the modelling process.

3.8.1 *Population and Employment*

The population was obtained from the 2011 Census Data and distributed between the zones. The total population after distribution between the zones compared well with the total population according to the 2011 Census Data.

3.8.2 *Private Network*

The private network of the previous model was taken as the basis. Recoding the network in the LWC-area was based on the latest aerial photographs. The rest of the network was corrected in terms of road upgrades that were recently done.

3.8.3 *Public Transport Network*

Routes for each public transport mode were updated independently as described earlier in the report, using the available data. The rail and MyCiTi routes are correct due to high quality data sets. The bus route data was not ideal, but the routes as represented in the model are a close match to reality. The minibus taxi route data in the 2010 model were carried over to the new model without change since there were no reliable minibus taxi route data sources to compare the routes in the old model against.

3.8.4 *Trip Generation and Attraction*

Trip Generation was based on the Household Travel survey (2013) and the regression equations obtained from this data source obtained acceptable coefficients of determination (R^2). R^2 is a measure of how well the regression model fits the real world data.

A R^2 of 1 is best and 0 is worst. A summary of the R^2's obtained are provided in Table 3-8. The R^2 for the Home-based Other trip purpose was not nearly as good compared to the other trip purposes, but the impact of this is small due to the low percentage share of this trip purpose.

Table 3-8: Trip Generation R^2

Trip Purpose	Income Group	R^2
Home-based Work	Low	0.9934
Home-based Work	Middle-low	0.9987
Home-based Work	Middle-high	0.9921
Home-based Work	High	0.9780
Home-based Education	Low	0.9950
Home-based Education	Middle-low	0.9993
Home-based Education	Middle-high	0.9963
Home-based Education	High	0.9982
Home-based Other	Low	0.6129
Home-based Other	Middle-low	0.5732
Home-based Other	Middle-high	0.7814

Home-based Other	High	0.6703

3.8.5 Trip Distribution

Due to the impracticality of displaying the calibration results of all the deterrence functions, one example will be used to illustrate the acceptability of the results for the deterrence functions. Macro zone 32, Blue Downs, is used as an example. The desire lines from this macro zone, calculated when using the normal gravity model applied to the household data is shown in Figure **3**-**36**.

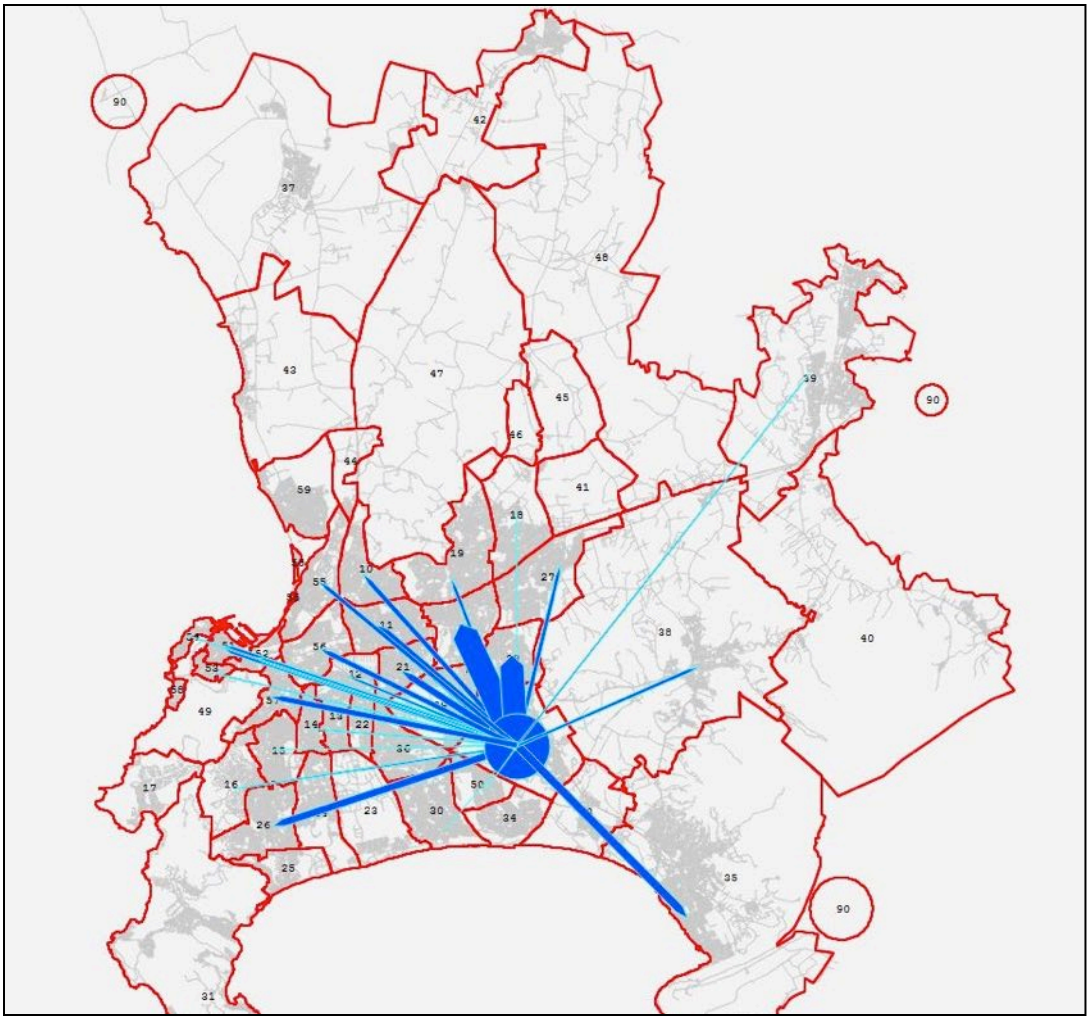


Figure 3-36: 2013 Desire Lines for Blue Downs according to the Household Data

A comparison of the trip length distribution according to the data and calibrated deterrence function for the Blue Downs is area is provided in Figure **3**-**37**. The modelled trip length distribution compares well with the trip length distribution according to the data. The average differs by 6% while the standard deviation differs by 2%.

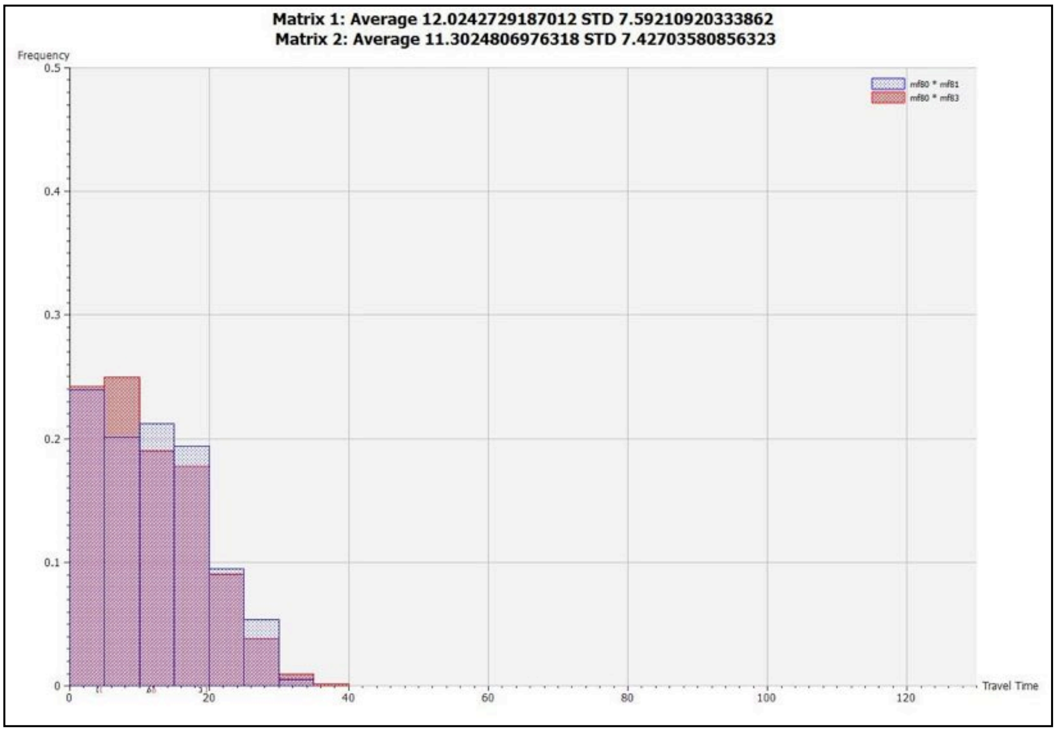


Figure 3-37: Trip Length Distribution Comparison

The calibrated deterrence function resulted in the desire lines as depicted in Figure **3**-**38**.

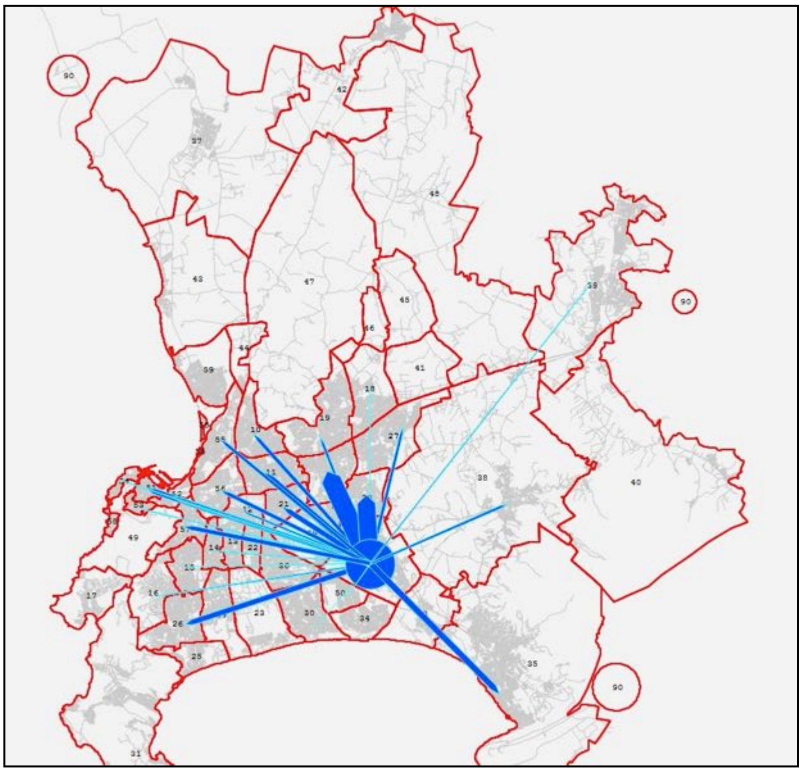


Figure 3-38: 2013 Modelled desire lines for Blue Downs

By comparing Figure **3**-**36** with Figure **3**-**38** it is clear that the model's trip distribution is acceptable.

3.8.6 *Modal Split*

Two sets of data were used in the development of the modal split model. The one set was used to develop the utility functions and the second set (the household data) was used to calibrate the modal split model. A comparison of the modelled with the household data set provides a R^2 of 0.966. The gradient is 1.06 and the curve cuts the origin, implying that the modal split results are acceptable. A scatter plot is provided in Figure **3-39** of the comparison of the modelled results.

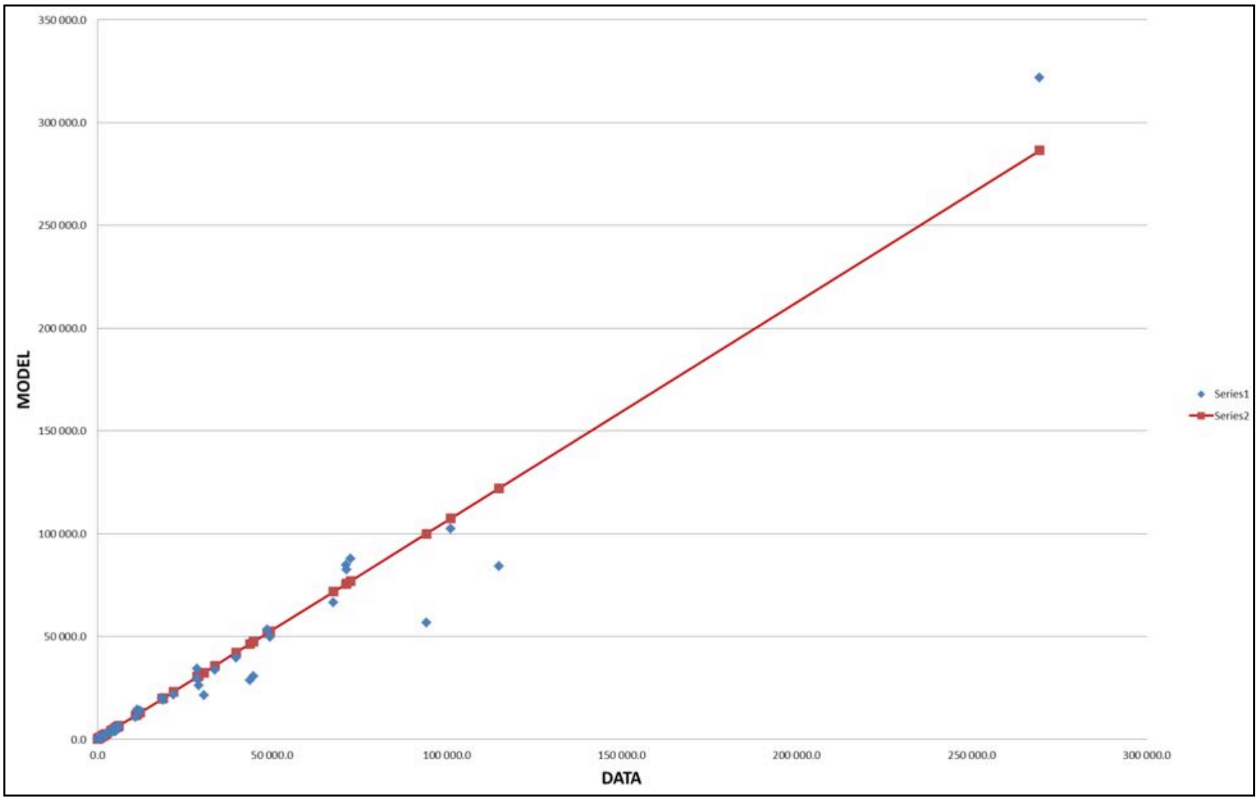


Figure 3-39: Modal Split Calibration Results

3.9 Model Validation

Classified traffic counts, bus on board survey and rail census data were used to validate the model.

3.9.1 *Private Vehicle Assignment Validation*

The cordon count data and other count data provided by the City of Cape Town were used to compare the private vehicle assignment results against. The regression revealed the following results:

- a = -16.302, which is close to 0 and thus acceptable
- b = 0.933, which is close to 1 and thus acceptable
- R^2 = 0.827, which is above 0.8 and thus acceptable

The scatter plot of the comparison is provided in Figure **3-40**.

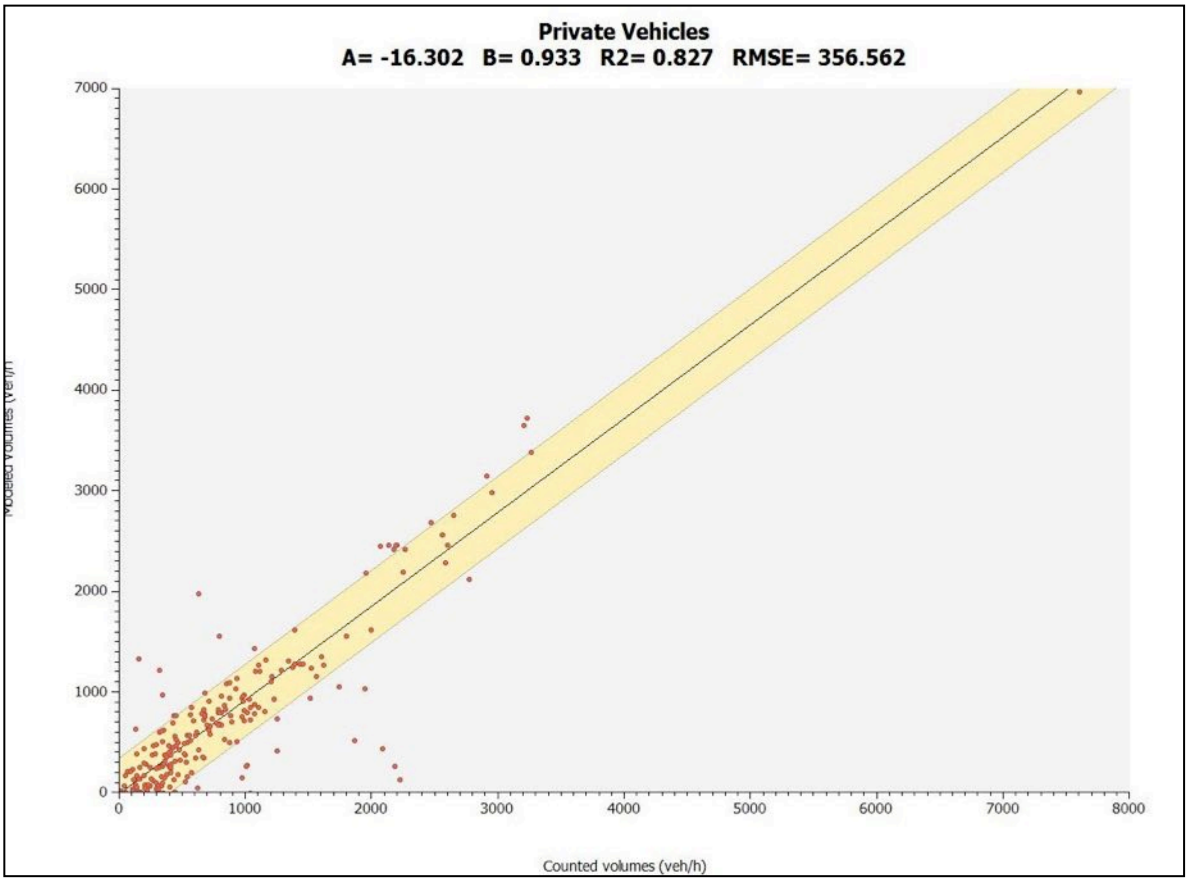


Figure 3-40: Private Vehicle Assignment Validation

3.9.2 Contracted Bus Assignment Validation

The contracted bus data used for the validation was the boarding counts collected during the on-board bus survey. This comparison was done on a macro zone level. The regression revealed the following results:

- a = 386.18
- b = 0.675
- R^2 = 0.771

Although the results were not as good as for the private vehicle assignment, it is considered acceptable when considering the quality of the bus data set that was received. The scatter plot of the comparison is provided in Figure **3-41**.

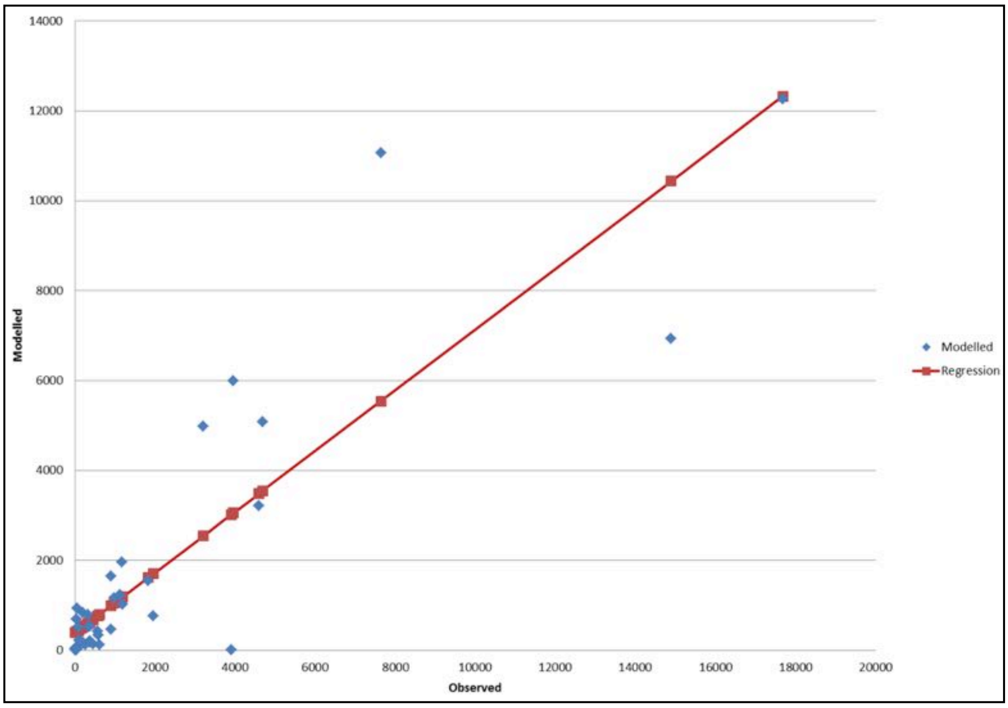


Figure 3-41: Bus Boarding Validation

3.9.3 Rail Assignment Validation

The rail census (2012) dataset obtained from the City of Cape Town was used to compare the rail assignment against the model results. This comparison was done on a link level and the regression revealed the following results:

- a = 22.942, which is close to 0 and thus acceptable
- b = 0.996, which is close to 1 and thus acceptable
- R^2 = 0.965, which is close to 1 and thus acceptable

The scatter plot of the comparison is provided in Figure **3**-**42**.

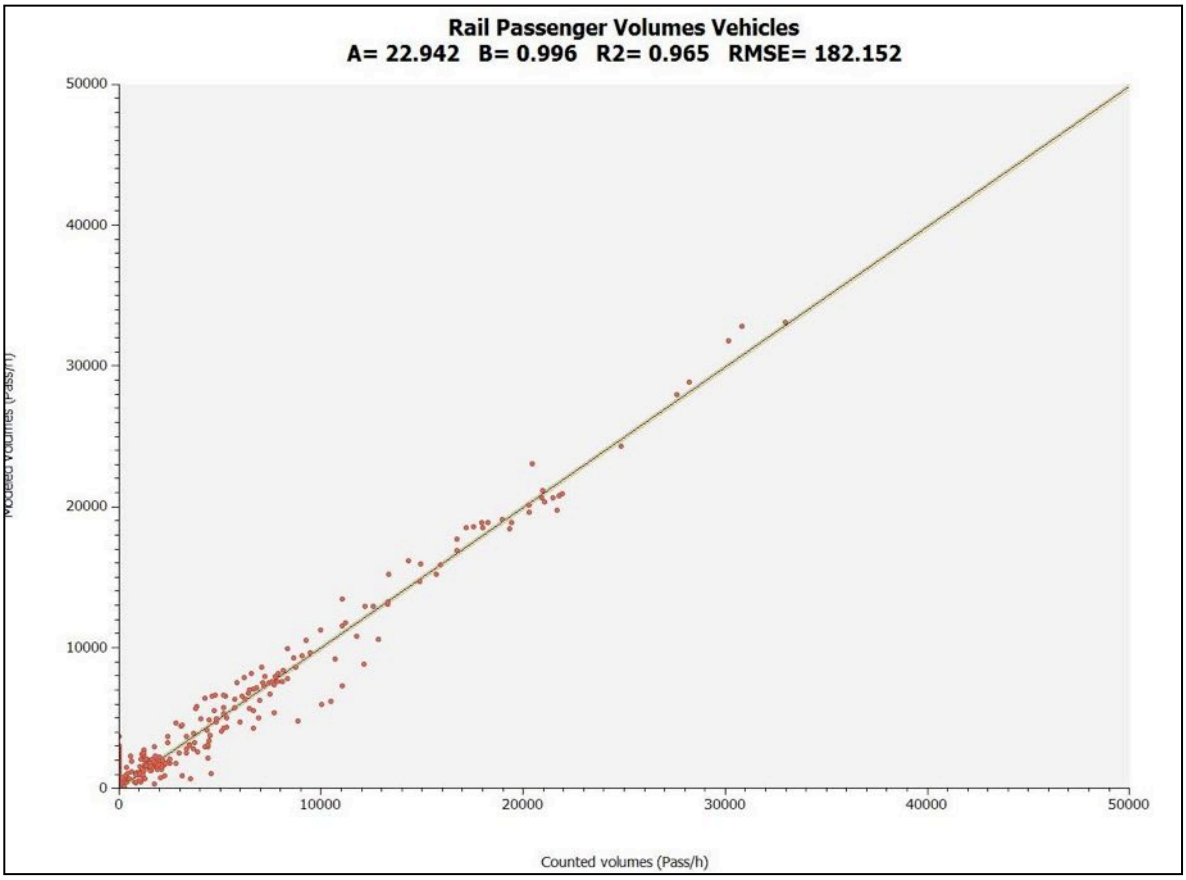


Figure 3-42: Rail Assignment Validation

3.9.4 Minibus Taxi Assignment Validation

Minibus taxi boarding count data were obtained from the City of Cape Town, but a number of uncertainties regarding this data lead to the conclusion not to do a comparison. The taxi assignment results is expected to be acceptable because the all the previous steps (trip production and attraction, trip distribution, modal split as well as the private, bus and rail validation) indicated acceptable results.

3.10 Conclusions and recommendations

3.10.1 Conclusions

The model developed for IPTN, Conceptual Design and Operational Plan for the IRT component of the LWC was an improvement over the 2010 model for the purposes of the these studies in terms of the following:

- Zone refinements:
  Zones were refined in the LWC area, zones outside the LWC area were corrected resulting in no gaps between zones. Zones now cover the whole modelled area and future zones are provided.
- Population:

The population is based on the 2011 census data and is thus up to date. Four income groups were introduced and the population categories were increased to eleven categories.

- Employment:
  Employment is based on the latest GLA and zoning data provided by the City of Cape Town. Four income groups were introduced and the employment categories were increased to 15. The employment data for the neighbouring towns are not to the same accuracy as that of Cape Town.
- Network refinements:
  The network represented in the model was refined for the LWC area and corrected for those links outside of the LWC to reflect the correct number of lanes and link type. The link types are sufficient, but the volume-delay functions revealed modelled speeds that are too high.
- Public Transport routes:
  Rail and MyCiTi routes are accurately reflected in the model. The accuracy of bus and minibus taxi routes in the model were improved with regard to route alignments, stops and stop times.
- Trip generation and attractions:
  Trip generation and attraction is done for each of the three trip purposes and four income groups and incorporates all of the population and employment categories.
- Trip distribution:
  The trip distribution model was vastly improved when compared to the 2010 model and not only takes into account the trip purpose and income group, but also the area characteristics. The intra zonal trips have also been updated based on the latest HTS.
- Modal split:
  A sophisticated modal split model was introduced that caters for all the modes and takes into account the quality of the service in terms of travel time, walk time, wait time, number of transfers and cost.
- Trip assignment: The trip assignment was improved and makes provision for the interdependence of the various modes.

The model was calibrated satisfactorily in accordance with the patterns reflected by the latest Household Travel Survey and the model validation based on count data indicated satisfactory results.

The model procedures and calculations were coded in a macro that not only saves time with regards to model runs, but also ensures consistency between various model runs.

3.10.2 Recommendations

The following recommendations are applicable:

- Zonal refinements:
  Refine the zones in the built-up areas outside of the LWC area to the same level of detail and size as the zones in the LWC area.
- Population:
  Split the school category between primary and secondary school learners.
- Employment:
  The GLA and land use datasets need to be updated and corrected for future modelling use as this is the only source of data that can be used to determine the employment as well the distribution of employment. This also applies to the GLA and land use data for the neighbouring towns covered in the model. Split the school category into primary and secondary learners. Introduce garden workers and house workers. Improve the accuracy of agriculture workers.
- Network Refinements:
  The network outside the LWC needs to be refined when the zones outside the LWC are refined. The link types are sufficient, but the volume-delay functions needs to be corrected.
- Public Transport Routes:
  Formal and informal agreements between the various minibus taxi associations need to be incorporated in the route data and all taxi ranks need to be included in the model. Bus and taxi routes for the neighbouring towns need to be obtained and incorporated in the model.
- Trip generation and attractions:
  The trip generation and attraction model is sufficient but needs refinement when additional population and employment categories are introduced.
- Trip Distribution:
  The trip distribution model is sufficient but needs to be recalibrated when the zones outside the LWC are refined.
- Modal Split:
  The modal split model is sufficient, but will need adjustment if a new mode is to be introduced in future.

The model developed for the City of Cape Town is not only up to date, but is now a valuable tool to be used for further analysis, not only in the field of planning, but also with regards to cost estimates, economic analysis, operations planning and design. However, due to changes in land use, population, travel patterns, and the like, the model will need to be updated regularly. The following update procedures are proposed:

- Two year cycles: Adjust the population and employment based on the total population and employment numbers, route data and traffic counts. If changes are dramatic this cycle can be reduced to annually.
- Five year cycles: Revise the population and employment totals as well as the distribution of the population and employment.
- Ten year cycles: Revised, update and recalibrate the model based on the census data as well as new Household Travel Survey data.

The above model update procedures will ensure that the model that remains up to date and relevant. This will also increase the life span of the model.

Due to the importance of data, not only with respect to model development but also with regard to keeping the model up to date and relevant, it is important that the following procedures are in place with regard to the data needed for modelling purposes:

- Plan and design the surveys needed for updating the model.
- Prepare a survey program.
- Set in place data validation procedures and data correction procedures.

4. URBAN GROWTH LAND USE SCENARIOS

4.1 Introduction

4.1.1 Background

The urban growth "Land Use Model" was developed as the land use component for the development of a city-wide Integrated Public Transport Network (IPTN). At approximately the same time, relevant planning documents that relate to and / or affect land use and land development were approved, namely:

- The Cape Town Spatial Development Framework (CTSDF) - approved in 2012;
- The Cape Town Zoning Scheme (CTZS) – promulgated towards the end of 2012, effective from the beginning of 2013;
- The Cape Town Densification Policy - approved in February 2012;
- General Valuation Roll (GV) of 2012.

This necessitated the review of the estimates related to land use (intensity) and presented an opportunity to standardize the base land use assumptions. The Transit Oriented Development Land Use Model" was developed in order to simulate the base year (2013) situation and to generate future land use scenarios. The development of this land use model however also provides the opportunity to potentially use the land use model in, amongst others, infrastructure planning, the identification of housing sites and the development charges work, provided purpose-specific adjustments are made, where necessary.

A separate document entitled *"Land Use Model: Urban Growth Modelling"* provides a detailed description of the urban growth modelling component of the Land Use Model. It includes technical information on the methodology and recommendations for how the model should be used.

4.1.2 Purpose of the Urban Growth Scenarios

The purpose of the model is to locate and quantify spatial growth estimates as an informant to other City activities. It was, specifically, developed as a component of the so-called *Land Use Model* to be used in the planning of the *Integrated Public Transport Network (ITPN)*. As such, equal focus is placed on residential growth (trip origins) and the growth of employment-generating land uses, such as office, retail and industrial (trip destinations/ generators).

The outputs of the land use model in terms of the "Pragmatic Transit Oriented Development" scenario and the "Pragmatic Densification" scenario of the model have also been adopted by other City departments as an indicator of where land development can realistically be expected in future. It is likely to be used in, amongst others, infrastructure development planning and budgeting, in the calculation of development contributions, in densification monitoring and other similar applications where anticipated land use plays a role. For these use cases certain assumptions will have to be modified for those specific purposes as necessary.

The model is simplistic in comparison to more complex urban growth prediction models in that it uses a combination of methods that are applied to specific subareas (called *development locations*). The expected output is to predict for selected time horizons the location of urban growth and to quantify those in terms of:

- The number of residential dwelling units (DUs) by income or housing market;
- The extent (measured in m² GLA) of business (retail or offices) and industrial land (manufacturing, warehousing or service industry).

4.1.3 Methodology

The methodology, basically, involves the quantification of the estimated land supply (land availability and land capacity) and the projected land demand (in particular the number of DUs to measure residential development and m² GLA to measure economic activity) and the spatial matching of the resultant transport supply and demand for travel. This required the identification and classification of development locations; the estimation of land availability and land capability; trend analyses and research; and the development of land use scenarios.

The modelling draws on and integrates previous and other related work and projects including other available data sets (the accuracies and completeness of these datasets varies), of which the following are the most significant:

- Undeveloped and /or Partially-Developed Land Inventory (UP-DLI)
- Economic Areas Management Programme (ECAMP)
- General Valuations Roll, 2012 (GV2012)
- The electronic version of the Cape Town Zoning Scheme, 2012 (CTZS 2012)
- Informal settlement surveys
- Backyard dwelling surveys

In addition, it also includes another essential component: specially-captured spatial information relating to land development potential.

4.1.4 Limitations

This work, in general, is subject to limitations stemming from imperfect information and future uncertainties (such as those related to the property market and the economy). It is impossible to make precise predictions for the future and this model should only be used to explore possible future outcomes given the assumptions upon which it is based.

Certain specific limitations are highlighted below:

- Brownfield sites require further investigation to better understand the development potential of these sites
- The model reflects both current development trends and what Spatial Planners view as desirable city growth within the confines of existing planning documents, such as the SDF and the District Plans. The future development of any site is, however, is subject to site-specific criteria and restrictions or requirements, that may be unknown at present or that may change with time.

- The realisation of any scenario presented in this document depends on synchronised land use management and deliberate efforts to attain the scenario as presented.

4.2 Land use scenarios

4.2.1 Development of scenarios

The land use scenarios illustrate different growth assumptions over the 20-year horizon.

The following points apply to all scenarios:

- The scenarios are hypothetical.
- They make assumptions about the land use, developability and development phasing of sites based on business intelligence and spatial plans.
- The aim is to vary scenarios as much as practically possible to illustrate different outcomes.
- They do not regard the non-availability of infrastructure as a constraint.
- They do not regard private land ownership as a constraint.
- They factor in possible constraints imposed by infrastructure and ownership through the time factor by shifting development to later years.
- They consider both residential and non-residential growth. For the IPTN modelling the spatial distribution of land use is important, as trips are generated between origin (trip production) and destination (trip attraction) land uses.
- They recognise that change of land use and increased land use intensity takes place gradually.
- They do not investigate tourist activities or freight movement because this is not required for the IPTN modelling.
- The scenarios exclude certain wildcard sites, but provide estimates for the excluded (portion of) sites to enable sensitivity-testing.
- The scenarios absolutely do not create any land use rights and should not create expectations in this respect.

The following key assumptions are common to all the scenarios:

- No new informal settlements are created. Informal settlement growth is limited to certain existing informal settlement locations that can accommodate further growth to a maximum number calculated based on the current median density of informal settlements.
- Brownfield development is applied to previously identified undeveloped and partially-developed residential properties smaller than 2500m² in all income ranges so as to simulate incremental densification.
- Certain wildcard sites are either included or excluded based on the classification system set out in the Urban Growth Modelling Land Use report. The wildcard sites are discussed in more detail below.

4.2.2 Variables and Assumptions

The main variables affecting the different scenarios relate to:

- Incomes or housing markets
- Housing development density and dwelling unit type
- Building density and building volume (bulk)
- The location of land development
- Anticipated economic growth (trends used as specified in the report detailed report

Assumptions were made concerning the land use, site developability, and development phasing of sites. Assumptions are based, as far as possible, on business intelligence, spatial plans and are informed by analysed trends.

Spatial allocation first prioritised infill areas (including activated wildcard locations), secondly brownfield locations, thirdly densification in Densification Priority Zones (DPZs) and lastly greenfield sites. Generally, sites where District Spatial Planners have captured data took precedence, as it ensured that the need for making any further assumptions was reduced.

4.2.3 Selection of scenarios

Three future (2032) land use scenarios were proposed to be tested during the transport demand modelling process. These were:

i) Business as Usual (BAU),

Residential development sees residential development taking place at historic trend densities and follows the north western and north eastern growth corridors (greenfield areas). New industrial and office developments continue to cluster in existing locations, while new retail development follows disposable income and locates in such a way that it is able to reach the threshold population that it requires.

ii) Pragmatic Transit Orientated Development (PTOD)),

Residential densification and non-residential land use intensification takes place in accordance with the principles of the Densification Policy with greater focus on transit orientated development locations. As in the previous land use scenario, new industrial and office development largely remains confined to known economic areas with new retail floor area locating where disposable income spatially goes.

iii) Transit Orientated Development Comprehensive (TODC),

Land development is spatially concentrated around high-order public transport infrastructure to support the latter, while residential and non-residential development is balanced to optimise public transport movements. All projected residential and non-residential development in the 20-year period is located in high-order transport precincts which results in spatial restructuring to test its impact on all aspects of public transport. This scenario is based in theory, and constitutes an ideal situation from a transport perspective – the realisation of which would require very specific commitment to policy, decision making and transversal practices; and a favourable reaction by the public sector and general public. In order to achieve the desired situation and comprehensively implement TOD principles, disruptive change is seen to be required,

These scenarios provide alternative pictures for how development could be spatially distributed in the future. The future development considered in these scenarios in terms of new dwelling units and non-residential development projections are the same in all the scenarios. The difference between the scenarios lies in the spatial allocation of development. The IPTN alternatives responded to the demand in one preferred land use scenario; this is namely the Pragmatic Transit Oriented Development land use scenario. Once a preferred network alternative is selected, this will be evaluated against the BAU and TOD scenarios to test the network's sensitivity to changes in land use.

A fourth land use scenario was initially developed called "Pragmatic Densification (PD") and the IPTN was initially proposed to be developed for this land use scenario. While the Pragmatic Densification (PD) land use scenario was seen as the most practical by the land use planners, the importance of land use on the design and on-going operating costs of a public transport network meant that a more sustainable land use scenario from a public transport network was believed to be necessary moving forward. For this reason the TCT Commissioner instructed the team not to use the PD scenario for testing the IPTN alternatives, but to instead use the PTOD land use scenario for building the network alternatives on. The sensitivity of the preferred network alternative must then be evaluated against the BAU scenario, as well as against a more comprehensive TOD scenario formulated by the City's spatial planning team. The Pragmatic Densification scenario was not used in the final planning of the IPTN.

4.2.4 Wildcards

Potential developments that contain a significant amount of uncertainty are termed wildcards. These developments are difficult to precisely quantify in terms of scale, intensity or mix, location of the development and/ or timeframes for implementation

Wildcard locations are classified based on underlying factors that introduce uncertainty, namely:

- **Strategic spatial planning sensitivity**, e.g. the level of compliance with strategic objectives or its alignment with the CTSDF
- **Location-based sensitivity** – whether it falls inside or outside of the urban edge and whether it is supported by Council or still under consideration/ in process.
- **Scale/ intensity/ land use mix-based sensitivity** – if no site development plan has been prepared, the scale/ intensity/ land use is unknown
- **Timeframe-based sensitivity** relates to unknown timeframes, long-term timeframes, "development readiness" (e.g. zoning, ownership), approvals in hand (e.g. environmental authorisation, other approvals)

The above sensitivity factors (strategic alignment, location, scale and timeframe) could also exist in combination and/ or include further unforeseen or unknown aspects, e.g. leadership direction (policies, incentives, etc.); development "ripening" (a site lends itself to being developed once certain things happen, e.g. the population threshold related to a commercial development is reached; infrastructure is upgraded enabling further development; accessibility is improved; etc.); economy; location-specific aspects (soil conditions, zoning overlays, local development incentives, etc.). It may also include developments that depend on the realisation of a number of interrelated factors or a combination of factors.

Depending on its classification, wildcard locations are either included in or excluded from the growth modelling. Wildcard developments were scored in terms of their uncertainty, as described above, and those developments that were considered significantly uncertain were not included in the land use scenarios. Two of the most significant wildcard areas considered were the Wescape area, north of Parklands, and the redevelopment of the Philipi Horticultural Area (excluding the southern corners). Both of these were excluded from the land use scenarios due to their classification as uncertain wildcards.

Details of all wildcards are included in the separate report on Urban Growth modelling which may be used separately for sensitivity analysis in respect of specific localities or a specific set of circumstances.

4.3 Land use scenario for the iptn: pragmatic tod

The Pragmatic Transit Oriented Development (TOD) land use scenario was developed from the Pragmatic Densification scenario that was ultimately not used in the IPTN planning process. The Pragmatic Densification land use scenario applied the principles of the *Densification Policy* at current trend densities. In the Pragmatic TOD scenario, however, density further increases and focuses on Densification Priority Zones (DPZs) in support of transit orientated development. The location of residential and non-residential developments in the IPTN's land use scenario, Pragmatic TOD, are indicated below in Figure **4-1** and Figure **4-2** respectively.

The key assumptions made in the development of this scenario were:

- Higher densities were applied using a scenario-specific density matrix that cross-tabulates income (housing market) and density (housing type).
- Density was further increased (by changing the values of the density matrix) in infill development locations, while a strong focus was also placed on DPZs. Densification in DPZs used a scoring system based on spatial location criteria developed adapted from the *CTDP*.
- Densification occurs in existing residential areas in housing markets where demand exist. Density thresholds were used to increase density in transport zones (TZs). In this manner, TZs that already have high densities were avoided and densities were spread more evenly between TZs.
- Second dwellings spawn from existing properties (all income ranges) along major movement corridors to simulate incremental densification in these target areas.
- Second dwellings in the low-income range occurred on both subsidy sites and gap housing sites in accordance with investigated ratios.
- The transformation of areas from middle income to lower middle income was simulated in certain parts of the city.

- Growth options areas ("Growth Option C") greenfield sites were activated where development was likely to take place or where development has already commenced or where land development applications have been approved.
- The proposed/ future *Blue Downs railway line* and the three railway stations have been included as DPZs.

Further details can be found in the detailed *"Land Use Model: Urban Growth Modelling"* report.

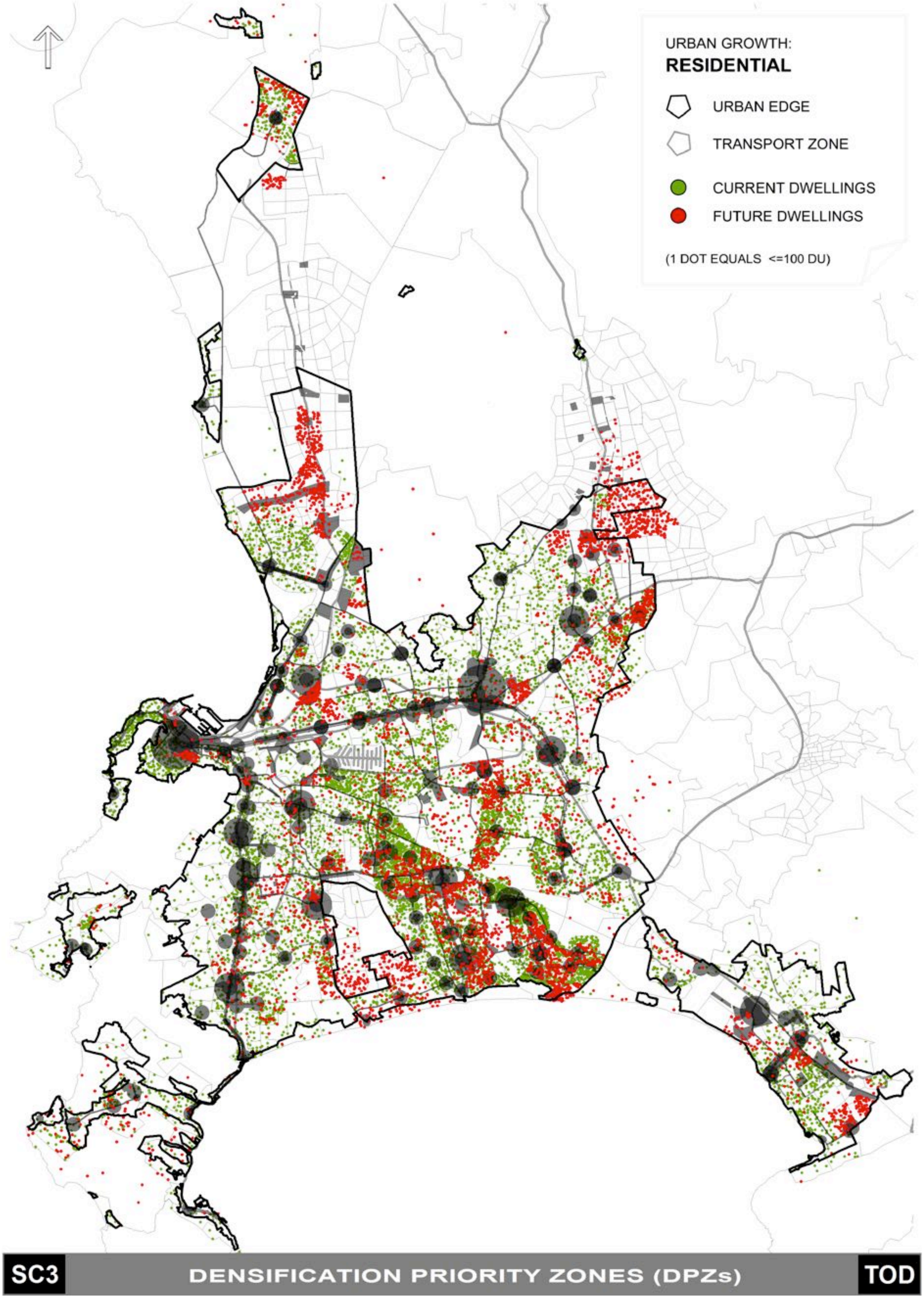


Figure 4-1: Pragmatic Transit Oriented Development land use scenario: residential developments (current and future) relative to Densification Priority Zones

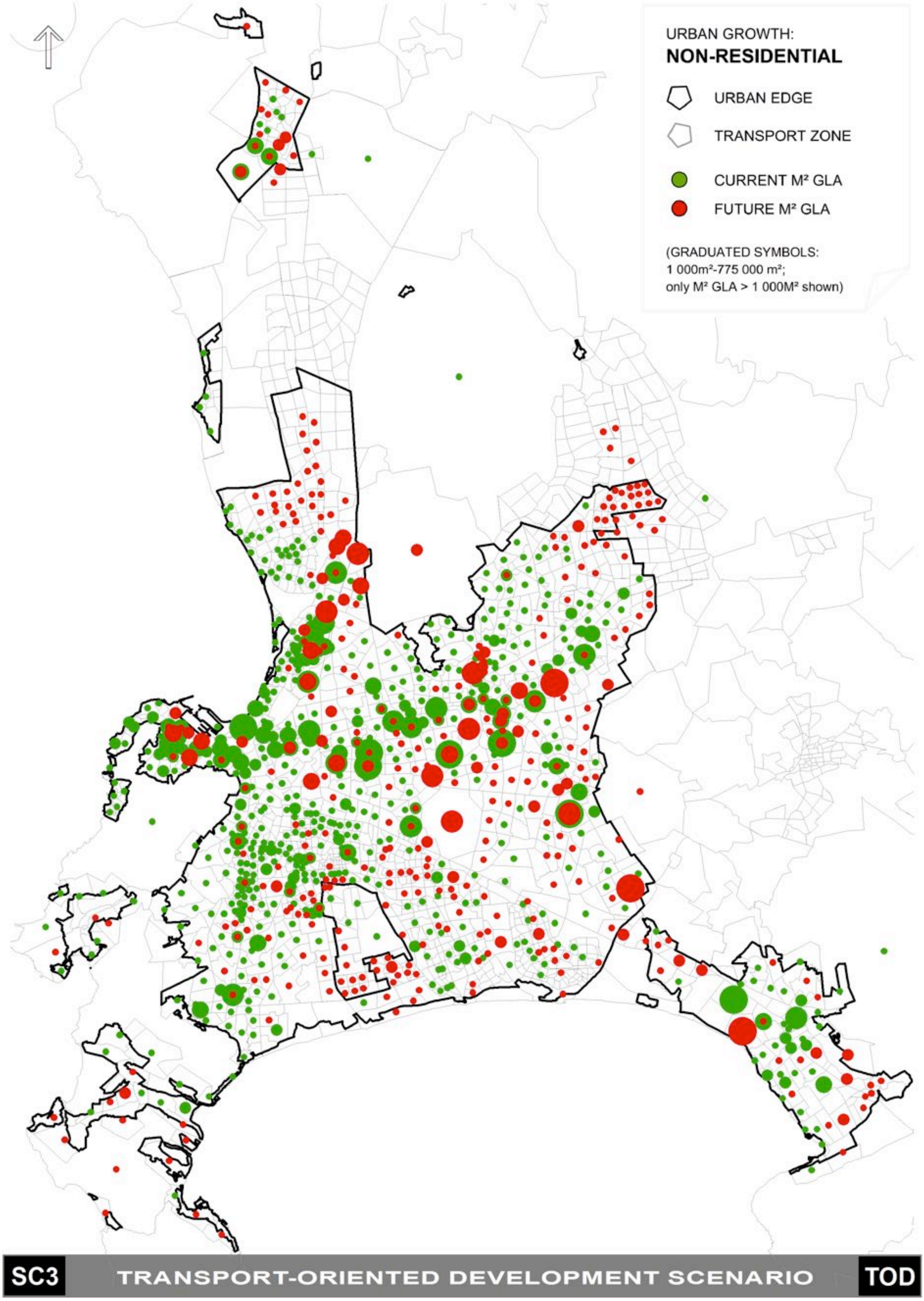


Figure 4-2: Pragmatic Transit Oriented Development land use scenario: non-residential developments (current and future)

4.4 Other land use scenarios

The IPTN network alternatives were based on the Pragmatic Transit-Oriented Development land use scenario in order to prepare an appropriate transport response to the future need for travel. Once the preferred network has been selected, this network was tested against two alternative land use scenarios to investigate what the effects on the network would be should development not occur as predicted in the Pragmatic Transit-Oriented Development land use scenario. These two other land use scenarios are described in this section and represent two extremes of how development could be located in the future. The "Business-as-Usual" land use scenario tests how the network performs should current development trends continue, and the "TOD Comprehensive" land use scenario tests how the network performs if Transit Oriented Development principles are pursued more aggressively.

4.4.1 "Business as Usual" land use scenario

In this scenario, land throughout the city develops in accordance with historic densities and development occurs in anticipated localities following historic trends.

The key assumptions made were:

- Historic density trends are applied using a scenario-specific density matrix based on the housing market (income-based) and by housing type.
- All identified available land across the city is utilised, but because of the lower densities employed, more greenfield land is required.
- Only selected greenfield sites that form part of "Growth Option C" are activated for settlement.
- Land development occurs where and how anticipated by District Spatial Planners.
- Informal settlement growth is accommodated in second dwellings and greenfield areas once the median density is reached.
- Second dwellings spawn from new subsidy and gap housing sites to simulate incremental densification.
- Very limited redevelopment and land use intensification takes place.

4.4.2 "TOD Comprehensive" land use scenario

4.4.2.1 An introduction to Transit Oriented Development

Planning literature contains multiple definitions on the concept of Transit Oriented Development. Most often it is used to describe an approach to development that responds to an integrated, hierarchical public transport network in relation to its intensity and density. "Transit Oriented Development" (TOD) is a term that encapsulates the process of focussing the development of housing, employment, activity sites and public services around existing or new railway stations served by frequent, high quality and efficient intra-urban rail services. TOD is designed to create a relatively high density, compact and mixed urban form. In the United States, TOD is now a very important part of a broader smart growth approach to urban development including new urbanism, urban infill, urban growth boundaries, historic preservation, affordable housing and inclusionary zoning. The concept of TOD, which focuses on the symbiotic relationship between urban development and transport, is used internationally to varying degrees in the Americas, Europe and Asia to create more liveable cities and make use of the land value capture, primarily associated with main public transport lines. South Africa's National Development Plan 2030 outlines "an approach to change" that indicates the cycle of development. This approach highlights social cohesion in the relationship between development and the quality of life of the citizens, a concept at the heart of TOD. The National Government's Priority Outcomes speak to TOD in three of the outcomes, namely:

- Outcome 6 – An effective, competitive and responsive economic infrastructure network
- Outcome 8 – Sustainable human settlements and an improved quality of household life
- Outcome 9 – Responsive, accountable, effective and efficient local government system

It is clear that TOD is a development strategy with a bias towards viable public transport and therefore speaks to urban form, development type, development intensity and development mix. The transport system must respond to urban development in a way that caters for the needs of passengers while remaining affordable to the city and its residents. Ultimately the interplay between public transport and urban development is considered reiterative and reinforcive. Whilst the provision of public transport responds to the existing form of urban environment, it can also be used, proactively, to drive sustainable and compact development. If the City adopts sustainable principles to stimulate development around public transport it will result in an affordable public transport system in Cape Town. In turn, a good public transport system can create improved development opportunities and reinforce urban development that supports public transport, making transport more efficient, affordable and accessible.

In conclusion, TOD, as it applies to the City of Cape Town, is proposed as the best long term development strategy to address spatial inequality, transport affordability and to arrest sprawl. It is driven by the integration of sustainable public transport and strategic land use intervention and built on the principles of affordability, accessibility, efficiency, intensification and densification.

4.4.2.2 TOD principles from a transport perspective

The following 5 principles highlight the TOD agenda from a transport perspective:

1) **Affordability** – reduce the cost of public transport to commuters and the cost of providing public transport to the City.
2) **Accessibility** – facilitate equal access to social and economic activity through strategic urban development and the provision of safe public transport.
3) **Efficiency** – provide an environment and level of service that reduces trip lengths and dependence on private vehicles.
4) **Intensification** & 5) **Densification** - manage the desired form, composition and location of urban development to make affordable, accessible and efficient public transport viable.

4.4.2.3 The following higher level strategies have been adopted to address the core principles of TOD:

i) Development in **close proximity** to high-order public transport.

This facilitates easy access to other city opportunities through the high-order public transport system (e.g. rail and dedicated right of ways on road) and promotes sustainable transport modes such as walking and using public transport in favour of the private car.

ii) **Mixed land use** development.

Residential development and economic activities are located in close proximity to each other. Providing a mix of development types promotes shorter trips to access opportunities. Short trips are less expensive (in terms of time and money) and can be made using non-motorised transport to access, amongst others, work, schools, community facilities and retail areas from home. Furthermore, this results in a public transport system that is efficiently used in both the peak and off-peak.

iii) Land use is mixed and distributed in order to **influence movement patterns**.

The mix of residential and economic activities is located along a corridor so as to facilitate bi-directional movement patterns. High-order public transport corridors that are associated with high levels of activity, through intense development, can make for a more efficient use of space and resources. This is particularly true if development is also located in a way that promotes travel in both directions throughout the day, with a greater number of shorter trips as opposed to fewer, longer single trips. It has been suggested that a public transport system, on average, does not break-even until surrounding densities are between 40-45du/ha and does not make a profit unless the surrounding densities are between 70-75du/ha.

4.4.2.4 Initial land use scenarios

The Integrated Public Transport Network (IPTN) initially requested three land use scenarios; Business-as-usual, Pragmatic Densification, and Pragmatic Transit Oriented Development. The overarching assumptions and resulting outcomes are briefly indicated below and then are discussed in terms of comprehensive transit oriented development.

"Business-as-usual" (BAU)

Basic assumptions: Development according to historic density trends based on current income patterns (spatial location of housing markets) in both infill and greenfield locations. The allocation of densities relates to the housing market and to zoning. The availability of services is not used to constrain development in this scenario. The current density averages are between 15-19 du/ha and will generally remain in this range in this land use scenario. The spatial distribution of the residential development in this scenario is indicated in Figure **4**-**3**.

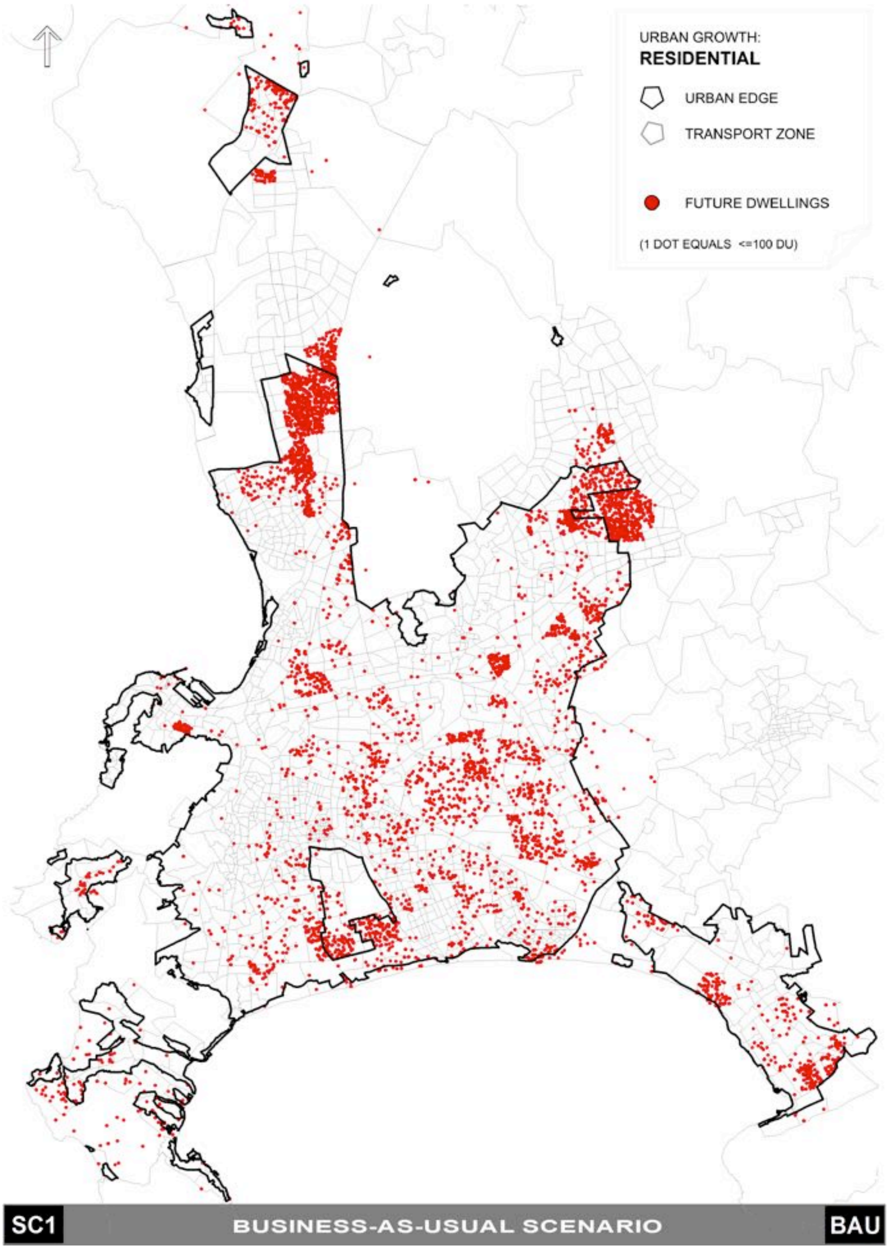


Figure 4-3: Business As Usual land use scenario: distribution of future residential development

Scenario Assessment/Conclusions

The bulk of residential growth is distributed in peripheral locations, exclusively on greenfield sites without increasing densities (due largely to the single-residential form of subsidy and GAP housing).

- If commensurate employment opportunities and social facilities do not locate similarly, this will mean substantially higher transport costs to the residents and more time spent travelling. It should be noted that transport costs are operational and are, therefore, an ongoing burden to the city and to its residents.

- This land use scenario also results in higher transport costs for the City due to additional kilometres of transport being provided. A sub-optimal mix of land use and densities hinders the efficient use of public transport which undermines the capacity provided by public transport and reduces the financial viability of providing the service.
- This scenario results in the perpetuation of the city's low densities and produces an unattractive urban form not conducive to development, thus making the city highly unsustainable and increasing inefficiencies.

"Pragmatic Densification" (PD)

Basic assumptions: Development builds on "Business-as-usual" scenario with densification in accordance with the principles of the Densification Policy. The spatial distribution of residential developments in this scenario is shown in Figure **4**-**4**

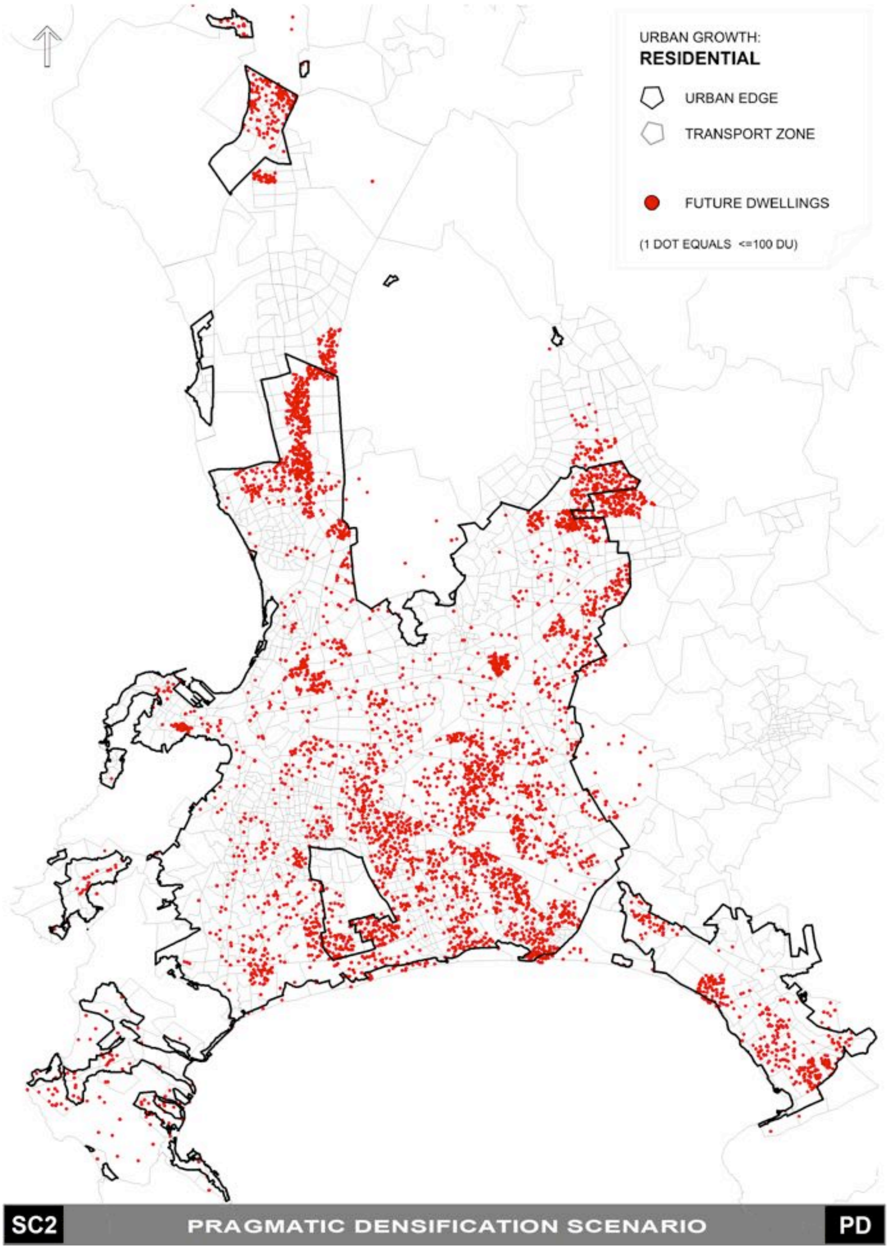


Figure 4-4: Pragmatic Densification land use scenario: distribution of future residential development

<u>Scenario Assessment/Conclusions</u>
In this land use scenario, which is not considered in IPTN modelling, the bulk of residential growth is assigned to the periphery, with considerably less development in greenfield areas and a marginal (general) increase in densities, ranging between 21-25 dwellings/ha.

- Again, if commensurate employment opportunities and social facilities do not locate similarly, this will mean higher transport costs to the residents and more time spent travelling. The transport services, remain uneconomical and a burden to the City and commuters alike.

- Placing additional residential development in the metro-south east exacerbates the existing one-directional inefficiency on the public transport-system i.e. trains are full travelling out of the MSE and empty on the return trip. Supporting residential development in this area induces immense strain on rail infrastructure in the same direction.
- Additionally, this scenario does not address the long distances between home and work, or what is known in the transport industry as dead mileage. Such a transport system is inefficient and unsustainable.

"Pragmatic Transit Oriented Development" (PTOD)

Basic assumptions: Densification in accordance with the principals of the Densification Policy and an improved focus on transit -orientated development.

Assumptions

- Specific densities are applied to the different housing markets (based on homogeneous valuation model regions)
- Density is further increased with the focus on Densification Priority Zones (DPZs). Densification in these areas uses a scoring system based on spatial location criteria adapted from the Densification Policy (2012).
- Infill development also occurs at higher densities.
- No new informal settlements are created. Growth is limited to certain locations that can accommodate further growth and to a maximum equal to the current median density of informal settlements.
- Brownfield development is encouraged at identified, undeveloped and partially-developed residential properties smaller than 2 500m².
- Densification occurs in existing residential areas in housing markets where demand exists. Density thresholds are used to increase density in Transport Zones (TZs). In this manner, TZs that already have high densities are avoided and densities are spread more evenly between these TZs.
- Second dwellings spawn from existing properties (all income ranges) along major movement corridors. These are developed in the low-income range occur on both subsidy sites and gap housing sites in accordance with investigated ratios.
- Growth options areas and greenfield sites are populated where development is likely to take place or where development has already commenced.
- The proposed Blue Downs railway link and its four (4) railway stations have been included as DPZs (Development Priority Zones), but because of the floodplains found to the west of the planned railway line, and the relatively few undeveloped and partially-developed land parcels in the area, relatively limited densification can occur in the vicinity of the planned railway line.

The resulting spatial distribution of residential development is indicated in Figure **4**-**5**.

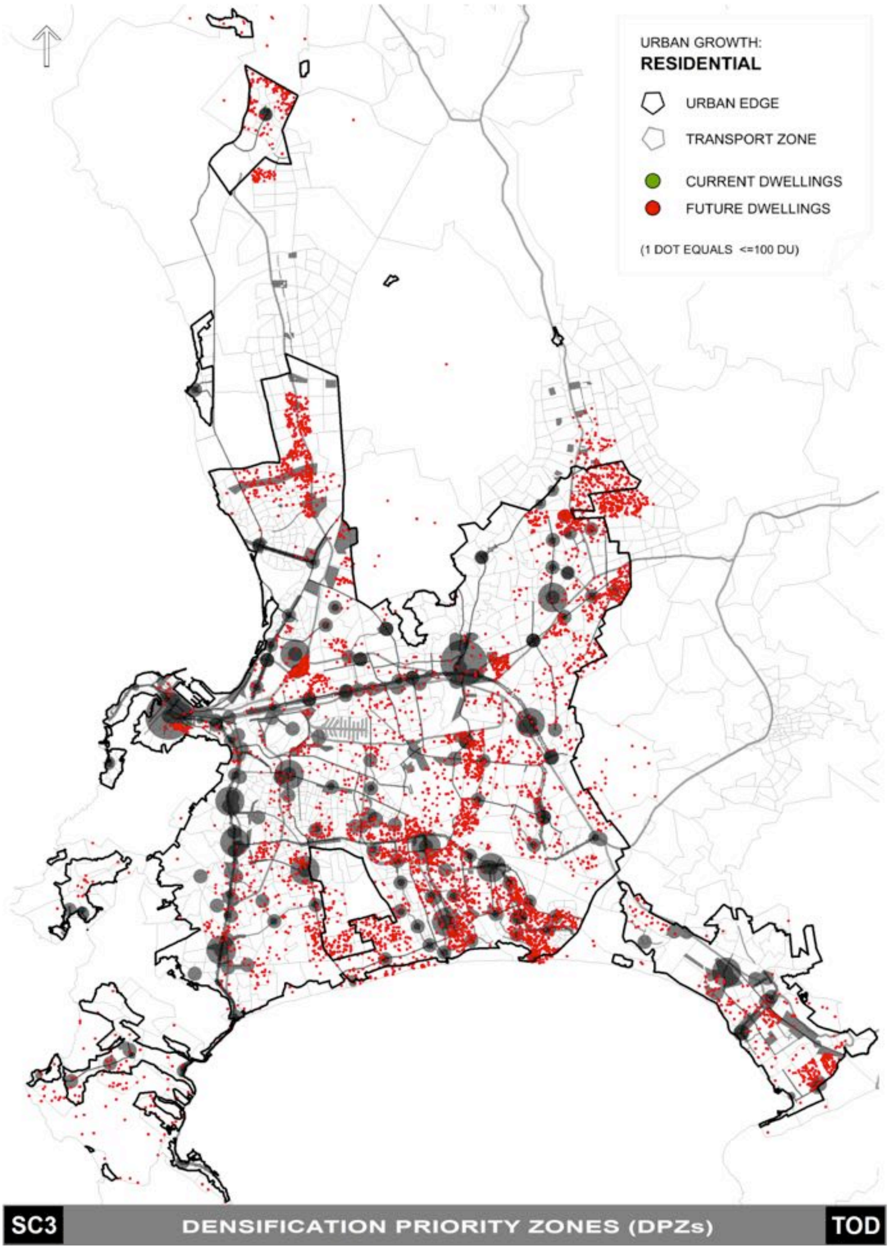


Figure 4-5: Pragmatic TOD land use scenario: distribution of future residential development relative to Densification Priority Zones

Scenario Assessment/Conclusion

In this scenario development is better located to support public transport when compared to the previous scenarios. The positive changes are highlighted in the circled areas on the above figure, where development is reduced on the periphery and development is allocated at higher densities around the public transport network. However the following observations are made that remain problematic in this land use scenario:

- Residential development and economic activities can be integrated to a greater extent.
- A greater degree of redevelopment can be considered at locations in close proximity to major transport infrastructure (i.e. around rail and road trunk stations). This land use model does not achieve the necessary intensification and densification required at trunk nodes.

- Greater intensity of land use and densities of up to75 du/ha (or more) in close proximity to high-order public transport stations have not been fully explored. This could be achieved through the uptake of unused land use rights, and in some cases complete redevelopment.
- Housing patterns have not changed substantially as low income groups continue to occupy traditionally low-density areas.
- The location of new developments does not take spare public transport capacity into account or efficiently optimise the use of the public transport in a multi-directional flow.
- Limited opportunities are available for creating significant development that is transit orientated as they are constrained by development trends. The spatial distribution of housing markets and the inertia of office and industrial development are examples of this, as there remains an economic disjuncture in integrated land use versus transport policy and related mechanisms.
- Finally, this land use scenario stops short of true investment

4.4.2.5 TOD Comprehensive: the proposed land use scenario assumptions

The last land use scenario, the comprehensive TOD land use scenario, requires a very specific commitment to policy, decision making and transversal practices. The intention of this land use scenario is to influence public transport movements by attempting to change land use patterns and facilitate a greater intensification of land use through investment-oriented public transport. The same number of new dwelling units and non-residential development is employed as in the previous land use scenarios, while making the following assumptions in Table 4-1:

Table 4-1: TOD Comprehensive assumptions

Assumption	Intention	Modelling mechanism
Household income and land value will not impact where residential development is located	To enable development to be located in a way that supports transit	Disregard land value and allow the spatial distribution of residential units to locate where strategically required
Development will be allocated to priority transit areas using existing theoretical maximum permissible/ deliverable rights, and then – if additional development is required – rezoning/ amendment of land use rights will be applied	To focus development in priority transit areas and make use of existing rights, but to allow for further development if the aforementioned is insufficient	Investigate current land use patterns/ mix (zoning). Make use of overlays to increase development potential (e.g. DPZs, PT1/2 zones, Urban Development Zone etc.)

		or decrease development potential where development is encumbered (e.g. road/ railway reserves, biodiversity areas, etc). Estimate the available rights using highest and best use assumptions
Parking requirements will be adjusted according to the provisions of Public Transport (PT) zones. If this reduction is not sufficient, further reductions will be modelled	To remove the restrictions placed on bulk[5] by reducing parking requirements	Apply reduced parking requirements to properties that fall within the PT1 and PT2 zones It will be assumed that parking will only be provided on site (i.e. around the building footprint and by making use of 1 basement parking level).
Land use intensity and land use mix is allocated according to best location for transit capacity utilisation	To use development type and mix in locations that take up existing, unused public transport capacity to use the public transport network more efficiently	Use existing volume/capacity ratios on transit network to allocate development
Development is geo-fenced to existing and planned higher order public transport infrastructure.	To illustrate the possible implications of concentrating development around the major public transport network in a way that supported the public transport network	Demarcate a TOD study area along existing high-order public transport infrastructure (BRT trunk and rail).

[5] Bulk is a commonly used term that refers to building magnitude in three dimensions. It is determined by applying all the development rules relating to a particular zoning, namely floor area ratio, coverage and height.

The implications of these assumptions are that spatial location and urban form are affected by achieving a higher level of density and greater intensity of land use. The relationships between the TOD principles and TOD Comprehensive land use scenario assumptions, implications and mechanisms are illustrated in the report on the land use model.

4.5 Conclusions and recommendations

4.5.1 Conclusions

The spatial distribution of development, both residential and non-residential, the location of these types of development relative to each other and relative to the main public transport network dictates, to a large degree, the public transport network that will be required to serve the City in the future.

The financial sustainability of the network can be optimised as far as possible but if the underlying demand for travel, as determined by the distribution of land uses, does not support public transport then the level of service that the public transport network can provide is significantly limited.

The potential long-term sustainability benefits to the public transport network of moving towards a transit oriented development approach to land use planning is significant and, therefore, the City should adopt the principles of Transit Oriented Development as outlined above and work towards implementing mechanisms to encourage TOD. Should development not occur in the transit-oriented way indicated in the land use scenario in the future, the public transport network developed in this project will not be the optimal network for that future picture.

In the process of developing the future land use scenarios for the IPTN project the Land Use Model was developed. This provides a useful tool for planning, not only for public transport but for other City utilities and other projects.

4.5.2 Recommendations

It is recommended that:

- The TOD Comprehensive assumptions outlined above be used to further develop a TOD Comprehensive land-use scenario.
- That the "Busniess as Usual" land use scenario developed in the urban growth modelling, and as outlined above be used in sensitivity testing going forward.
- The preferred IPTN Transport Network alternative is assessed on the "Business as Usual" land use scenario and the "TOD Comprehensive" land use scenario in order to under-stand the implications for the network should Cape Town develop in either one of these directions.
- The City's departments engage in working towards implementing mechanisms to en-courage TOD.

5. Development of IPTN alternatives

5.1 Introduction

This chapter describes the methodology and assumptions used in the development of transport network alternatives that were tested by means of the EMME transport demand model and then evaluated with a multi-criteria analysis process to determine the preferred long term network for which an operational plan and phased implementation programme will be prepared.

The objective in developing a long term IPTN is to determine a combination of routes, modes and operations which will best serve the mobility needs of the population and offer a viable alternative to increasing car usage. The sustainability of the public transport system will depend to a large extent on the City's success with increasing the density of land use in the public transport corridors and in reducing travel time by public transport to be competitive with travel by car.

5.2 Network Development Methodology

The process of developing integrated public transport network alternatives for testing with the calibrated EMME transport model for future land use scenarios over a 20-year forecast period was based on an analysis of the following information:

- Transport plans and strategies prepared by the City, the Province, the DOT and PRASA. The IPTN network design targets contained in the City's 2013-2018 ITP were used with regard to the threshold capacities and desirable station/stop spacing for Rail, BRT and Feeder routes. The table of network design targets is included at the end of chapter 2 (Status Quo Evaluation).

- Current public transport routes, operations, passenger counts and needs assessment. These are summarized from the Status Quo Review and Evaluation Report (September 2013) in chapter 2.

- Travel demand patterns revealed from the 2013 household travel survey, which are also contained in the above mentioned Status Quo report.

- Spatial Development Framework and Densification Policy of the City, which was used in the preparation of the land use scenarios that are described in chapter 4.

- Origin-destination desire lines based on 2032 population and employment projections for the pragmatic TOD land use scenario. The desire lines for public transport trips in the morning peak hour are shown in Figure 5-1 and Figure 5-2 for different passenger volume categories. Figure 5-1indicates the volumes for public transport trips for a volume above 6000 trips and Figure 5-2 indicates the public transport trips for a volume of between 2500 and 4000 (grey) as well as 4000 to 6000 (blue).

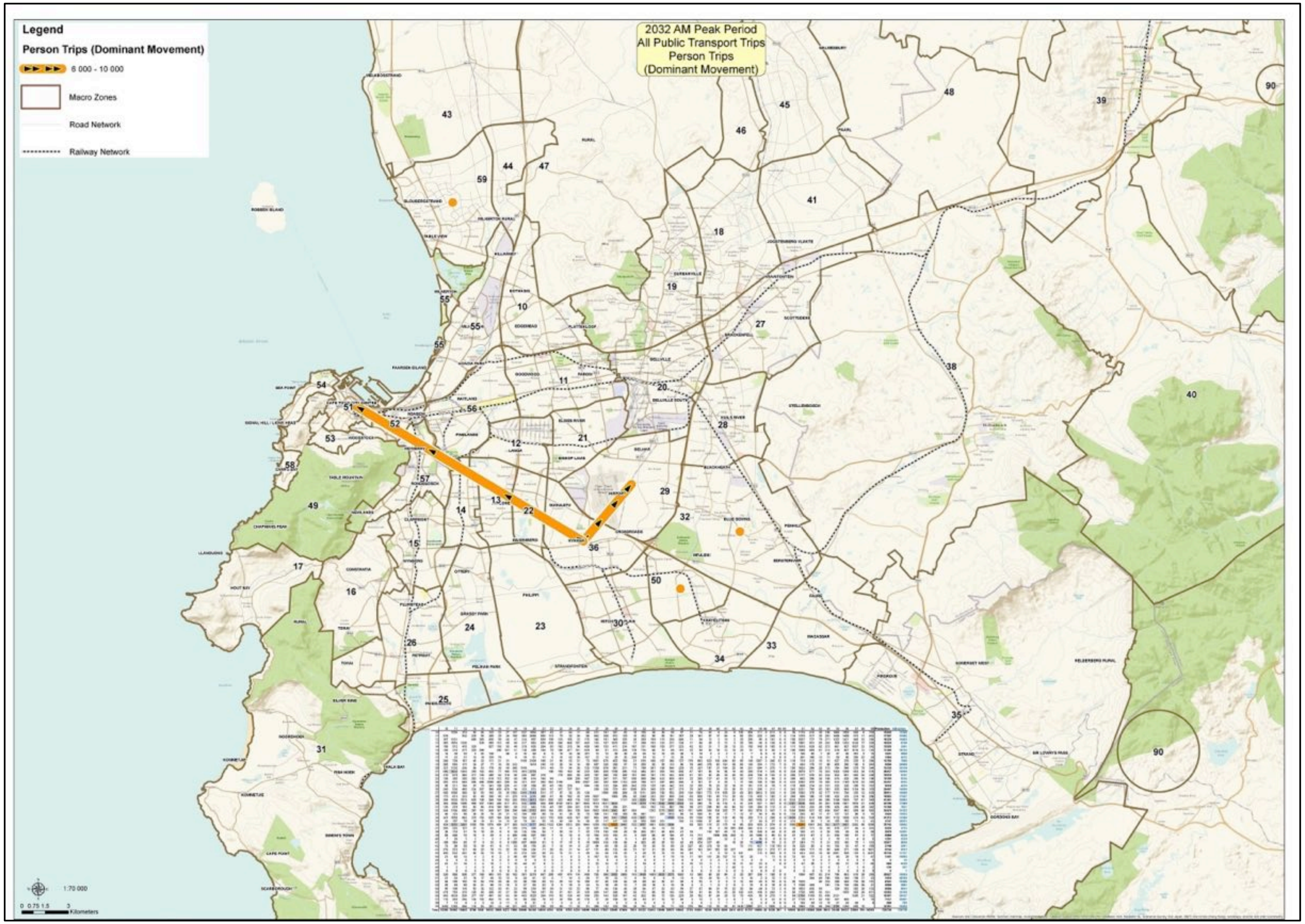


Figure 5-1: Morning Peak Hour Public Transport Travel Demand: less than 6 000 pass/hr/direction (2032)

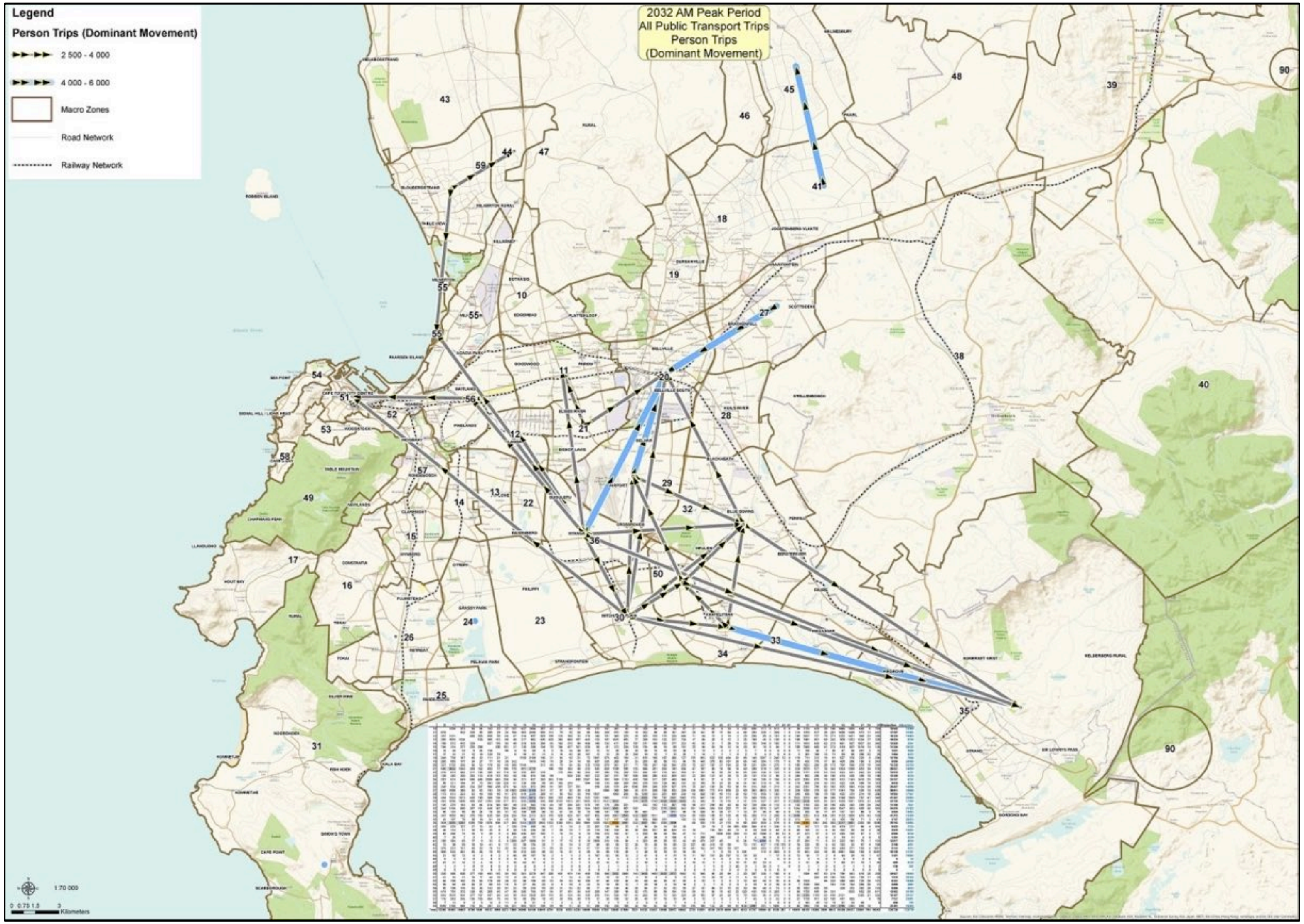


Figure 5-2: Morning Peak Hour Public Transport Travel Demand: less than 6 000 pass/hr/direction (2032)

Three alternative public transport networks, referred to as TA1, TA2 and TA3 were prepared for initial testing with the EMME travel demand model. The outputs from the travel demand model and the cost model (described in chapter 8) were then used to undertake an initial assessment of the three alternatives with regard to passenger volumes, travel time and operating cost. From this initial assessment, two further alternatives (TA4 and TA5) were developed to improve upon the initial alternatives. The five alternative networks are described briefly below, before a detailed discussion of the characteristics of each alternative is provided.

- **TA1** – This is the base alternative against which the others are compared. It assumes that the existing public transport operations will continue, with only Phase 1 of MyCiTi being completed and PRASA's currently committed signal modernization, station upgrades and new rolling stock project being completed. Future land use development is assumed to be served by expansion of the existing minibus taxi and GABS routes.

- **TA2** – This is a rail emphasized alternative which extends the current network with the following commuter rail lines: Blue Downs, Atlantis, Fisantekraal, and a Khayelitsha – Somerset West link. In other corridors which are estimated to have between 4 000 and 10 000 passengers per hour per direction according to the 2032 travel desire lines, BRT trunk routes have been included in the network.

- **TA3** – In this network the proposed commuter rail lines in TA2 which were shown by the EMME travel demand model to carry less than 10 000 passengers per hour per direction in 2032 were replaced with BRT trunk routes or distributor routes. This was the case for the Atlantis and Fisantekraal lines. Some distributor and feeder routes which carried more than 2 000 passengers per hour in TA2 were changed to BRT routes in TA3.

- **TA4** – The cost modeling of the TA2 and TA3 operations indicated that these networks have substantial operating deficits for the 2032 PTOD land use scenario. In order to reduce the deficit, scheduled feeder bus routes that contributed most to the deficit were replaced by unscheduled minibus taxis which were assumed to be able to cover their operating costs. 80% of scheduled feeder bus routes had to be replaced with unscheduled minibus taxis to reduce the deficit to an affordable level. The trunk routes in TA4 are based on a refinement of TA3 which had a lower deficit than TA2.

- **TA5** – This was a refinement of TA3 to reduce the operating deficit by assuming that the high peak hour demand can be spread over a two hour period, by limiting the supplied service on BRT routes to 90 second headways, which results in a lower bus fleet and fewer drivers than for TA3. In addition, a lesser number of scheduled feeder bus routes (20% compared to 80% in TA4) were replaced by unscheduled minibus taxis to reach a financial break-even situation.

In all of the above networks, the trunk routes (rail and BRT) are supported by a system of distributor and feeder routes which are designed to achieve the ITP objective of providing a scheduled public transport service to 80% of the metropolitan population within 500m walking distance to a public transport station or stop.

5.3 Transport Network Alternative One (TA1)

5.3.1 Introduction

This alternative was used as the base or benchmark network against which all the other proposed transport alternatives were assessed and evaluated using a multi-criteria analysis (discussed in chapters 9) in order to select a preferred long term network. The assumptions which were made in the preparation of this so-called "do minimum" alternative are explained below with regard to routes, infrastructure and services. A map of the TA1 network is shown in Figure 5-3.

BRT

It is assumed that the full Phase 1 of MyCiTi trunk and feeder services will have been implemented by 2032, including the proposed N2 Express services from Khayelitsha and Mitchells Plain to the Civic Centre. Although further phases of MyCiTi are also likely to be implemented by 2032, these are included in the other network alternatives. The TA1 network is therefore a theoretical "do minimum" benchmark against which to assess the benefits of "doing something" in other alternative networks.

Bus and Minibus-taxi Services

All bus services operated by GABS and Sibanye and all minibus-taxi operations, with the exception of those removed during the Phase 1 MyCiTi implementation, will continue to operate and will expand as the city expands and as passenger demand increases. No route or service rationalisation (other than for Phase 1) or increases in vehicle capacities are assumed, apart from an increase in the sizes of the respective vehicle fleets to handle normal growth in travel demand.

Rail

Improvements in rail service will result from the signalling upgrade project which will enable reduced train headways from 6 minutes to 3 minutes. The introduction of new rolling stock and an increase in the number of train sets will result in an increase in passenger capacity provided per hour. It is still unclear as to when the capacity increases will be realised, however, the signalling contract has already been awarded and the upgrade is expected to be completed in approximately 5 years. The supply of new rolling stock contract has also been awarded and indications are that new train sets will start to be delivered in 2016. Initially these will merely replace old unserviceable train sets, until an actual increase in the fleet size occurs in approximately 7 to 10 years time.

5.3.2 Infrastructure

Rail

The TA1 base alternative does not include any additional rail infrastructure other than some station upgrades, which will not materially affect the passenger capacity of the rail system. Increases in capacity, by means of a reduction in minimum possible headways from 6 minutes to 3 minutes through the implementation of the signalling upgrade project, as well as the acquisition of new rolling stock, will effectively double the theoretical passenger capacity of the system, if sufficient rolling stock is available. The increase in capacity is included in the 20 year (2032) travel demand modelling.

Road

The TA1 alternative includes approved[6] road schemes and other infrastructure projects related to the Phase 1 MyCiTi implementation. New arterial roads assumed for construction by 2032 include extension of the R300 westwards from the M7 to the M3, as well as the extension of Sheffield Road westwards from Philippi to Ottery. In addition to these roads, numerous local access streets will be provided to new residential and industrial areas that are developed.

New Road Ways

BRT

The only new busways in TA1 will be the completion of the "red lanes" under construction in the north western part of the City for Phase 1B of MyCiTi. These are along Koeberg, Racecourse, Omuramba and Ratanga roads, which are situated between Milnerton and Century City.

Bus and Minibus-taxi routes

No new roads will be constructed specifically for bus and minibus-taxi routes, but these operators are assumed to use the new roads and streets which will be provided as part of the City's planned road schemes referred to above.

Existing Road Ways

BRT

The R27 between Sandown Road and the Civic Centre, as well as Du Noon, Potsdam, and Blaauwberg roads are the only existing trunk routes that are included in the TA1 alternative.

Facilities

BRT Terminals

The following existing and proposed terminals are included in this alternative;

- Atlantis,
- Bay Side / Table View,
- Usasaza,
- Century City,
- Omuramba,
- Civic Centre,
- Waterfront.

All of these terminals have been built to accommodate only high-floor buses although some have been equipped with low-floor platforms for the feeder buses.

Closed Stations

[6] Projects that have planning approval and are likely to be constructed by 2032.

The following list of 29 route stations have already been brought into service and are equipped with high-floor platforms, with 6 of these stations (indicated as + feeder) where local feeder routes interface, also having low-platforms specifically for use by the 9m low-floor buses;

- Melkbosstrand + feeder,
- Sandown,
- Porterfield,
- Du Noon,
- Killarney,
- Potsdam + feeder,
- Circle,
- Wood + feeder,
- Jansens,
- Grey,
- Sunset Beach,
- Racecourse,
- Milnerton,
- Woodbridge,
- Lagoon Beach,
- Zoarvlei,
- Vrystaat,
- Section,
- Neptune,
- Paardeneiland,
- Woodstock,
- Thibault Square,
- Stadium,
- Granger Bay Boulevard,
- Refinery,
- Montague Gardens + feeder,
- Turf Club,
- Sandrift + feeder,
- Joe Slovo + feeder.

Open BRT Stations

There are no open type BRT stations being planned for the existing MyCiTi Phase 1 implementation, however on the N2 Express services all stops within Khayelitsha and Mitchells Plain will be kerbside open stops, similar to the feeder stops in Phase 1. Passengers will need to tap their card on the fare validator on entering the vehicle.

Feeder Stops

All the existing and planned Phase 1 feeder routes have been provided with open stops, some with shelters, to enable passengers to board the feeder buses. Fare payment is on boarding the vehicle. No further expansion of the feeder route network is planned after the full Phase 1 has been implemented.

5.3.3 Services

Rail

For purposes of this network alternative the various services that are operated by Metrorail are assumed to continue. However as previously mentioned, the modernisation programme for signalling and rolling stock will result in increases in capacity through reduction of headways and increase in train carrying capacities over the next 5 to 10 years.

Road

BRT

The MyCiTi Phase 1 services are assumed to increase in frequency in order to cater for increased passenger demand. This means an increased number of vehicles providing service and reduction in headways.

Hours of Operation

Currently the MyCiTi hours of operation are from 05:00 to 23:00 daily, but this could be extended if the demand is sufficient to warrant starting earlier and/or ending later.

Types of Vehicle

The existing vehicle types are retained in the 2032 transport model. However, if the headways are reduced to less than 2 minutes in the peak hour to cater for increased demand, investigations into obtaining larger capacity vehicles should be undertaken. Longer vehicles may require re-engineering of stations and passing areas.

Headways

Currently the MyCiTi trunk services operate with a peak period headway of 8 minutes and a maximum off-peak headway of 30 minutes. As demand on the routes increases, the peak period headways could be reduced to a minimum of 2 minutes, but at this level of operation, congestion in the bus lanes could become a problem, slowing down the running times and having an effect on other traffic at intersections.

Bus Routes

For alternative TA1 the current GABS and Sibanye bus services are assumed to remain in operation and be extended pragmatically in response to new developments occurring within and around the City. The vehicle fleet will be expanded and modernised as demand increases. It is assumed that these bus operators will continue to receive subsidies in terms of the contract with the Provincial Department of Transport or, once successfully ceded, under contract with TCT.

Hours of Operation

The majority of current GABS and Sibanye services operate between the hours of 05h00 and 22h00 daily, with a few special services operating outside these hours. The services operate seven days a week, albeit at reduced frequency on weekends and public holidays.

Types of Vehicle

It is assumed that GABS and Sibanye will continue to operate a fleet of predominantly 12m commuter buses, with a small amount of 14m bogey and 18m articulated vehicles on busy routes. The fleet of double deck buses will be systematically reduced as these vehicles age and are not replaced.

Headways

Very few of the current bus services can be considered to have regular headways, as the scheduling of the services is done to meet the peak demand and to provide efficiency in vehicle and staff utilisation. The timetables indicate that a certain number of trips per hour are scheduled, rather than departures being at specific times.

Minibus-taxi Routes

Similar to what was discussed in the Bus Routes section above, the minibus-taxi services will expand to meet increased demand and provide services to and from new development areas in a pragmatic manner.

Hours of Operation

The majority of minibus-taxis will continue to operate between approximately 05h00 and 19h00; outside these times only specially arranged or contracted services will be operated.

Types of Vehicle

Predominantly 15 - 18 seater minibuses will continue to be utilised for these services, although a limited number of midibuses (18 - 35 seater) may replace the smaller vehicles by some operators who are more entrepreneurial.

Headways

As the minibus-taxi services are essentially unscheduled, headways are flexible. As with the GABS bus services, the manner of describing the service is the number of trips in an hour (frequency) and this changes from hour to hour depending on the demand.

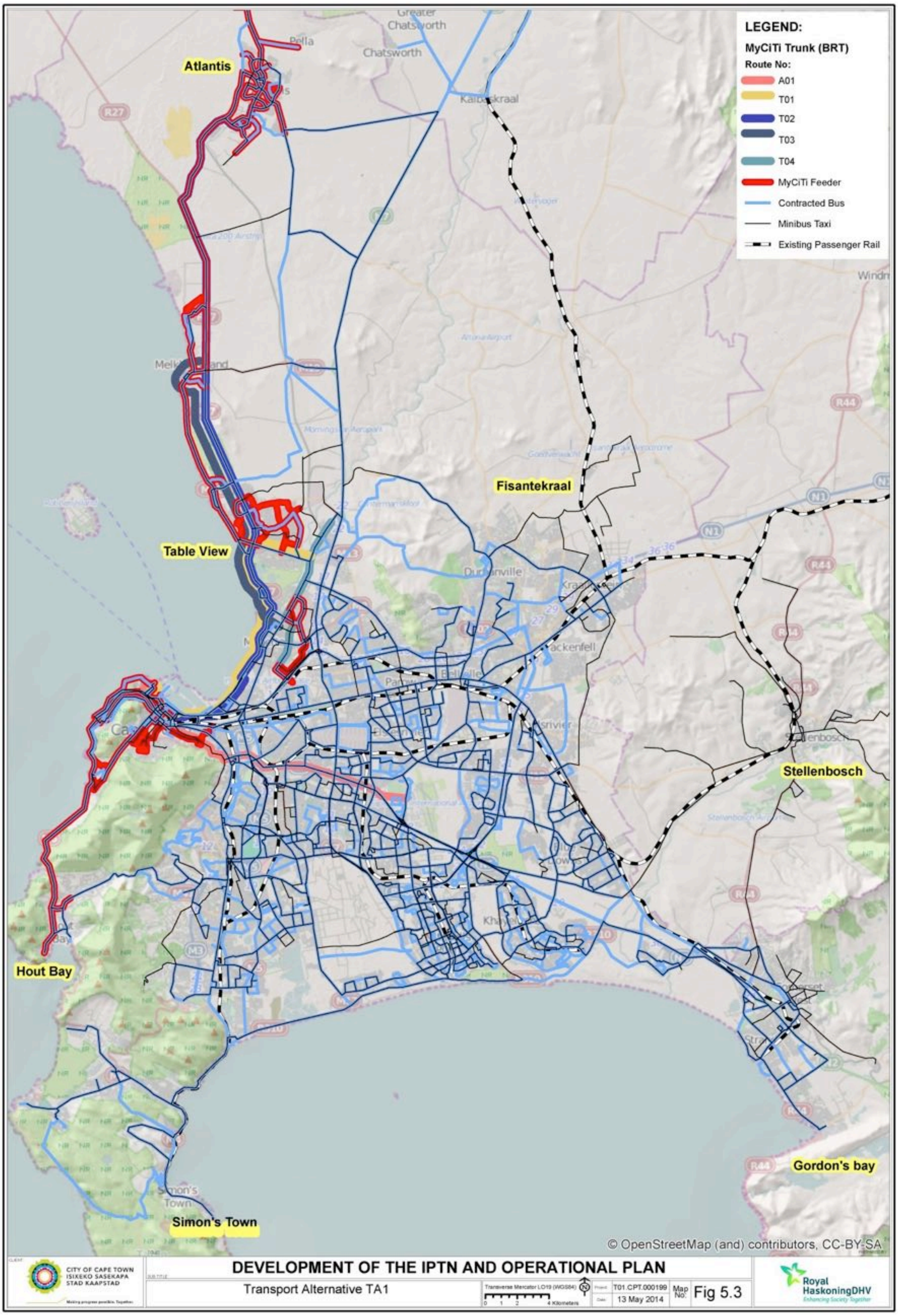


Figure 5-3: Transport Alternative TA1

5.4 Transport Network Alternative Two (TA2)

5.4.1 Introduction

This alternative reinforces the role of rail as the dominant mode for moving large volumes of passengers in the main mobility corridors of the City, supplemented by road based BRT services in corridors which do not have sufficient passenger demand in the next 20 years to warrant the provision of new rail services. A demand of 10 000 passengers per hour per direction is used as the threshold for the introduction of a new rail line. The integrated rail and BRT trunk services are supported by a network of scheduled feeder and distributor routes with the objective that 80 per cent of the metropolitan population should be within 500m of a public transport stop/station. The remaining 20% of the population is assumed to be served by the current unscheduled minibus taxi operators. A map of the TA2 network is shown in Figure 5-4.

5.4.2 Infrastructure

Rail

The future travel demand which will result from the City's land use densification and transit oriented development policies indicates that each of the following commuter lines proposed in PRASA's Western Cape Strategic Rail Plan may carry more than 10 000 passengers per peak hour by 2030 and they are included in the TA2 network alternative:

- Blue Downs rail line from Nolungile station to Kuilsriver station, providing a direct link between the Metro South East residential suburbs and the Blackheath, Kuilsriver and Bellville commercial and industrial employment areas. The expected high peak hour passenger demand on this line indicates that it should be constructed as a double track with proposed stations at Mfuleni, Blue Downs and Wimbledon. This new line is approximately 9 km long.
- Upgrading the existing Atlantis freight line for commuter use with electrification and passenger stations at Summer Greens, Chempet, Kynoch, Caltex, Du Noon, Parklands, Bloubergsvlei and Atlantis. The entire Atlantis line was tested in the travel demand model to see what peak hour passenger volumes are generated along the line in 2032.
- First stage of doubling and electrifying the Malmesbury line for commuter use between Kraaifontein station and Fisantekraal station, including upgrading of Fisantekraal station and providing a new station at Joostenburg.
- Extension of the commuter rail line from Chris Hani station to Firgrove station via Macassar, which will enable direct rail services between Khayelitsha and Somerset West. Although this is mentioned as a long term option, possibly for light rail technology, in the PRASA Western Cape Strategic Rail Plan (2012), the City's TOD scenario indicates that approximately 15 000 passengers per peak hour may be generated on this route by 2032.
- New rail stations on existing rail lines at Philippi West and at Bloekombos which is situated east of Kraaifontein station.

The capacity increases which are envisaged to result from PRASA's programme for modernisation of the signalling system and upgrading of stations to enable reduced headways and express train services, as discussed for TA1, are also included in TA2.

Road

The existing road network as used in alternative TA1 will have the following additions for BRT to supplement the rail services in alternative TA2:

New Road Ways

BRT Routes

- T11 from Khayelitsa to Wynberg via Jeff Masemola, Govan Mbeki, Strandfontein, Ottery, South, Waterbury and Main roads requires new road construction for BRT alongside the existing South Road, with a new bridge under the railway to connect the trunk route to Main Road along a reconstruction of Waterbury Road. Furthermore, due to the existing narrow two-lane section of Main Road through Wynberg, it is proposed to construct a new two lane road as a one-way couplet parallel to, and west of, Main Road by connecting Brodie Road with Tenby Road through properties that have been acquired by the City over the last 20 years for the proposed Wynberg bypass scheme. The MyCiTi buses will run in mixed traffic in a northbound direction along this new couplet road section, turning eastwards at either Church Road or Riverstone Road to return southbound in mixed traffic on Main Road which will operate one-way from Riverstone Road to Rockley Road. The section of Main Road between Rockley Road and Waterbury Road will be upgraded to a four-lane road, with buses operating in mixed traffic in the kerbside lanes northbound and southbound. The new South Road will be constructed with a median busway.
- T12 from Mitchells Plain to Claremont rail station will follow AZ Berman Drive, Stock Road, Govan Mbeki Road, Jan Smuts Drive, Turfhall, Racecourse, Doncaster, Chichester and Iman Haron roads. It requires the construction of second carriageways along Stock Road and Jan Smuts Drive. The single carriageway two-lane sections of Chichester and Iman Haron roads cannot be widened without property expropriation, so the initial transport modelling tested a single-lane westbound busway with buses returning eastbound in mixed traffic on these roads.
- T13 from Mitchells Plain to Durbanville will follow Eisleben Road, Jeff Masemola Road, Symphony Way, Robert Sobukwe Road, a proposed new link from Voortrekker Road to Durban Road, Willie van Schoor Avenue, Durbanville Avenue and Wellington Road to the terminus at New Street. Second carriageways will be required along New Eisleben Road, Jeff Masemola Road and Symphony Way and a new link road will be needed for a busway from Robert Sobukwe/Voortrekker Road intersection to Durban Road. Road widening is required along sections of Durbanville Avenue.
- Trunk routes 14, 15 and 16 are included in network alternative TA3 but have been excluded from TA2 to test whether the expanded rail network is sufficient to handle the demand without these.
- T17 from Khayelitsha CBD to Century City follows Spine Road, Mew Way, Jeff Masemola, New Eisleben, Klipfontein, Borcherds Quarry, Robert Sobukwe, Valhalla Drive, Nigeria Way (a new road south of Epping Industrial), Jan Smuts Drive, Prestige Drive extension with a viaduct over the rail lines west of Kentemade Station and a new busway along the southern edge of the N1 to Sable Road and then to Ratanga Road, where it will interface with the high floor trunk route T04 and feeder routes provided in Phase 1, which will distribute transferring passengers to Century City, Montague Gardens and further destinations along Koeberg Road. The proposed route along Nigeria Way requires a ramp for the busway to get to and from the median of

Valhalla Drive, as well as a viaduct to get from the western end of Nigeria Way to the median of Jan Smuts Drive over the adjacent railway.

Distributor and Feeder Routes

Distributor routes operate over longer distances than feeder routes and are complimentary to Rail and BRT routes, serving nodes along the routes and generally carrying less passenger volume than trunk routes. The following three routes are distributor routes in the TA2 network.

- D01 from Brackenfell to Tableview via Durbanville and Tygerberg Road (M13).
- D02 from Mitchells Plain to Cape Town CBD via Klipfontein Road to Main Road (Mowbray) and along Victoria Road. This route has peak hour public transport lanes along Klipfontein and Victoria roads.
- D03 from Hanover Park to Bellville via Turf Hall, Duinefontein and Robert Sobukwe roads.

There are 90 new feeder routes for the TA2 network, in addition to the 31 feeder routes being provided as part of Phase 1 of MyCiTi. The feeder routes connect to the rail stations and BRT stations, as well as serving local community travel needs. Feeder and distributor services operate in mixed traffic, except for sections of D02 which has lanes for peak hour usage by buses and minibus taxis only.

Existing Road Ways

BRT Routes

Bus lanes have been assumed to be provided in the median of existing dual carriageway roads for modelling the 2032 travel demand. The number of existing traffic lanes has been retained in the model, which can be achieved by either widening the road, or if this cannot be done, by removing kerbside parking.

Single carriageway roads will need to be widened to accommodate a two-lane median busway, but if this requires extensive property expropriation along the route, consideration needs to be given to providing only a single lane busway in the peak direction, which means that buses will operate in mixed traffic on their return trip.

If traffic volumes on existing roads are relatively low in both directions in the peak hours, buses can operate in mixed traffic with open kerbside stops, provided that the number of passengers boarding and alighting at these stops does not result in bus dwell time exceeding one-third of the headway time in the peak period, which will result in buses bunching at stops. If alighting and boarding passengers at a stop exceeds 400 per hour direction, closed stations are required.

Facilities

BRT Terminals

Each of the new BRT routes will require a closed terminal station at either end of the route, where buses can turn around. Space should be provided for buses to wait for the departure time before approaching the loading platform. In addition, sufficient feeder drop-off and loading platforms will also need to be provided.

Closed Route Stations

Each BRT route will have closed stations that are located in the median, strategically spaced to support the land use, serve pedestrian desire lines and facilitate transfers with feeder and distributor routes. Stops have been located at intersections along the trunk routes with an average spacing of 800m used as a guideline to select the closest appropriate intersection for demand modelling.

Open Stations

If traffic volumes on existing roads are relatively low in both directions in the peak hours, buses can operate in mixed traffic with open kerbside stops, provided that the number of passengers boarding and alighting at these stops does not result in bus dwell time exceeding one-third of the minimum headway time in the peak period. Open stops have been proposed along the sections of trunk routes T11, T12, T13 and T17 in Khayelitsha and Mitchells Plain, south of the R300 expressway.

Feeder and Distributor Route Stops

These routes operate in mixed traffic and are designed to provide access for people whose trip origin or destination is more than 500m from a rail or road trunk route station. The feeder routes have been designed to enable 80% of the City's population to be within 500m of a public transport stop. The feeder routes are based mostly on existing bus and taxi routes and stops have been rationalised to a spacing of 400m – 500m along these routes.

5.4.3 Services

Rail

Hours of Operation

It is assumed that the hours of operation for the commuter rail service will be the same as for the MyCiTi bus service to ensure integration of these services in all respects, i.e, physically, fare wise and in timetables. The policy guideline for IPTN operations as set out in the City's ITP is for 18 hours per day from 04:00 to 22:00. However, this guideline can be changed if the results of the demand and operational cost modelling show that large deficits will occur. These are normally attributable to low passenger utilisation in the off-peak periods and one method of reducing the deficit is to reduce or withdraw service in these low periods of utilisation.

Types of Vehicle

For the 2032 demand model it is assumed that all the existing train sets will have been replaced by the new PRASA rolling stock which will replace existing old train sets over a 10 year period commencing in 2016. Information obtained from PRASA indicates that a new 12 coach train set will be capable of carrying 2430 passengers if all coaches are Metro class. Metro-Plus coaches have 15% less capacity than Metro class due to the transverse seating layout which reduces the standing area.

Headways

Current train headways are limited to 6 minutes (10 trains per hour) per direction on a double line, mainly due to safety factors associated with the outdated signalling system. The replacement of the outdated train control system with a more modern train control system will enable train headways to be reduced to 3 minutes (20 trains per hour). This is assumed to be in operation on all rail lines in Cape Town by 2030.

Road

Hours of Operation

All MyCiTi services are assumed to operate for 18 hours per day from 04:00 to 22:00 for the cost modelling of the IPTN alternatives based on the 2032 passenger demand forecasts.

Types of Vehicle

The 2032 demand modelling was done assuming the following vehicle sizes:

- Trunk routes – 18m low floor articulated buses – 110 passenger capacity,
- Distributor routes – 12m low entry buses – 80 passenger capacity,
- Feeder routes – 9m low entry buses – 45 passenger capacity.

All these bus types will have doors on both sides of the vehicle so that they can serve passengers at either left side open stops are right side closed median stations.

Headways

An initial headway of 5 minutes was entered into the 2032 peak hour model for all scheduled trunk, distributor and feeder services. Depending on the resulting demand on each route, the model determines the headway required to serve the calculated peak hour passengers with the specified vehicle size for each route.

For trunk routes, it is not advisable to have headways of less than 2 minutes, to avoid bunching of buses at stops. If the passenger demand on trunk routes requires headways less than this, multiple platform stops and express services need to be provided.

If the passenger demand on distributor routes indicates that a headway of less than 5 minutes is necessary, as in the case of Klipfontein Road (D02) consideration was given to providing separate bus lanes on the busy sections of these routes, which also may require median closed stations if the alighting and boarding passengers at any stop cannot be handled through a single door on the left side of the bus.

If the passenger demand on feeder routes indicates that headways of 5 minutes is not sufficient with a 9m bus, a 12m bus will then be used on this route in the peak periods and replaced with a 9m vehicle in the off peak, assigned from another route where it is only used in the peak periods. The off peak periods were not modelled in EMME, but for purposes of cost modelling a headway of 20 minutes was assumed for trunk, distributor and feeder services.

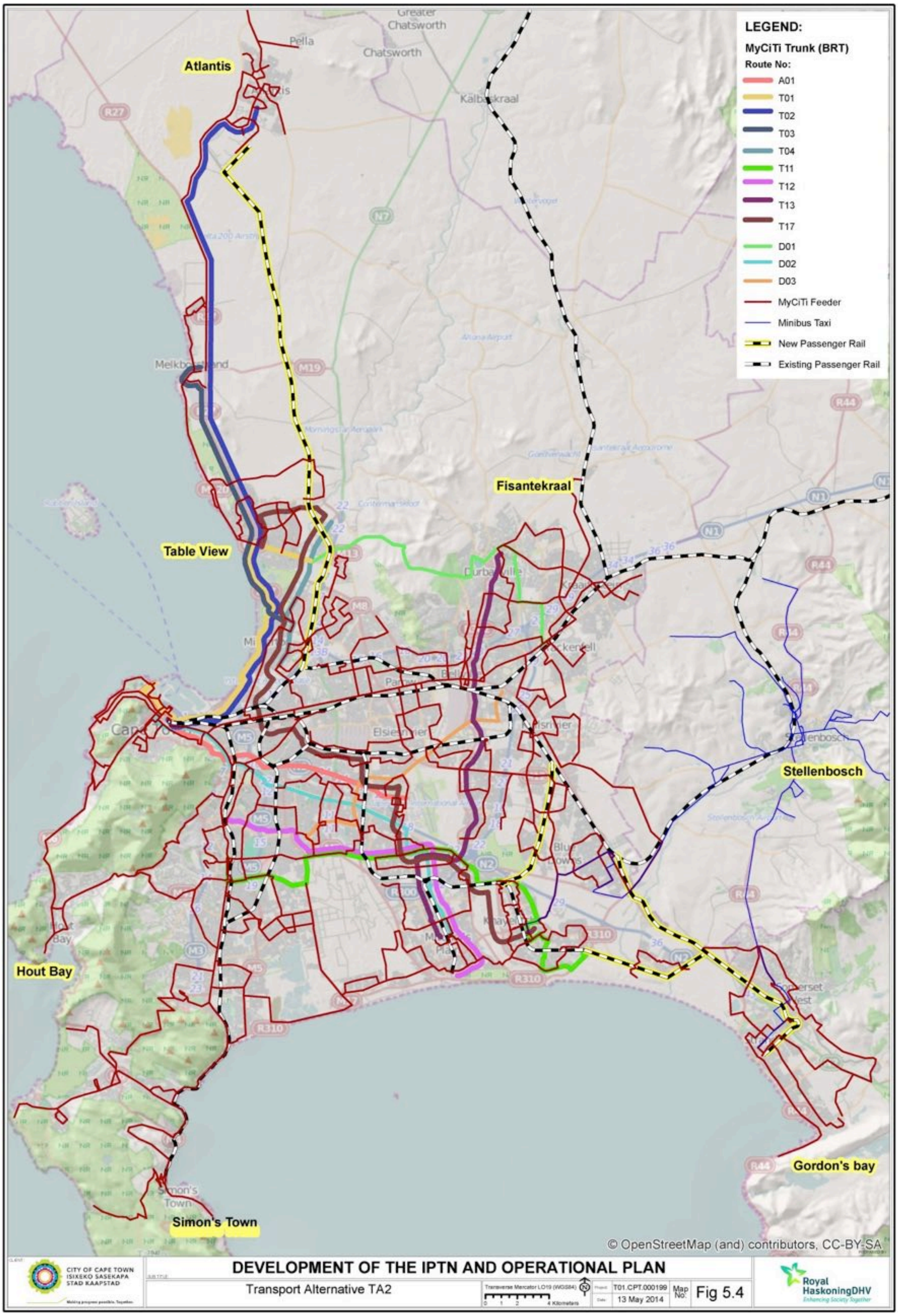


Figure 5-4: Transport Alternative TA2

5.5 Transport Network Alternative Three (TA3)

5.5.1 Introduction

This alternative is less rigorous than TA2 in increasing the capacity of the rail network and includes only the Blue Downs line as a new line which is expected to carry more than 20 000 passengers per hour per direction by 2030. The Atlantis line, Fisantekraal line doubling and Chris Hani to Firgrove line were excluded from TA3 in order to test whether BRT can handle the passenger demand in these corridors. For the existing line from Kraaifontein to Fisantekraal, it is assumed that the planned electrification will take place and Fisantekraal station will be upgraded with proper passenger facilities. The rail capacity enhancements due to the modernization programme are assumed to be the same as for TA1 and TA2, which are:

- Replacement and increase in number of rail coaches
- Upgrade of stations to provide for longer trains and express services
- Upgrade of signaling system to enable shorter operating headways

The following BRT trunk routes are included in the TA3 network:

- Westlake - Strand
- Wynberg - Khayelitsha
- Claremont -Mitchells Plain
- Mitchells Plain - Durbanville
- Retreat - Bellville
- Strandfontein – CBD
- Eersterivier - Parklands
- Khayelitsha – Century City
- Wallacedene – Century City

A system of Distributor and Feeder routes is linked to the rail and BRT network at selected stations to provide a similar coverage as for TA2, namely 80 percentage of the future population distribution is within 500m of a public transport stop. A map of the TA3 network is shown in Figure 5-5.

5.5.2 Infrastructure

Rail

The new infrastructure required for the assumed additions to the existing rail network for TA3 consists of:

- Blue Downs line between Nolungile and Kuilsrivier stations.
    - o It is assumed that this new line, which is about 9km long, will be electrified and consist of a double track with three stations along its length, at Mfuleni, Blue Downs and Wimbledon.
    - o At the southern end, the line should include connections to/from Nolungile station and to/from Nonkqubela station.
    - o At the northern end, connections will only permit trains to operate to/from Kuilsrivier Station and not to/from Blackheath station.
- Malmesbury – Fisantekraal – Kraaifontien existing line.
    - o Electrification from Kraaifontein to Fisantekraal,
    - o Improved signalling,

- Construction of commuter stations at Joostenberg and Fisantekraal.

Road

The following improvements are required to the existing road network for the provision of median busways for the proposed BRT routes:

New Roadways

BRT Routes.

- Extension of Giel Basson Drive(M12) from Sienna Drive north of Burgundy Estate and Richwood, over the M13 and N7, linking with Potsdam Road and extending westwards on the new bridge over the rail to link with Sandown Road, then northwards to a new development and westwards to a terminus in Big Bay. This route will ultimately be a four-lane dual carriageway road with dedicated median bus lanes and approximately 5 stations from Plattekloof Road to Sandown Road;
- Extension of Prestige Drive northwards from Voortrekker Road through Maitland and provision of a new busway viaduct over the rail lines west of Kentemade station, with ramps from the viaduct down to ground between the rail lines and the N1. The east facing ramp will serve the BRT route to Century City via the Sable Road bridge over the N1 and the west facing ramp from the viaduct will serve a new busway leading under the Koeberg interchange bridges and over the Salt River Canal to connect with the existing Phase 1 busway to the Civic Centre on the south side of its underpass under the N1;
- Extension of Frans Conradie Drive(M25) from Vanguard Drive westwards through Wingfield and over the rail line at Century City station to link with the bridge over the N1 at Sable Road.
- A new road (Nigeria Way), with dedicated bus lanes, linking Valhalla Drive and Jan Smuts Drive along the southern side of Epping Industrial between the rail line and Bofors Circle, passing underneath Vanguard Drive at the rail bridge;
- Extension of Ottery Road west of the M5 into a new carriageway along the southern side of South Road through to Main Road, with a planned rail underpass south of Wittebome Station;
- New Link from Baden Powell Drive, west of the Coastal Park landfill site, to the proposed alignment of the M42 (eastern extension of Steenberg Road)between Vrygrond and Lavender Hill, linking with the M5. Alternatively, the link from Baden Powell Drive to the extension of Military Rd in Lavender Hill;
- New road to link Charl Malan Drive (Bellville) to Durban Rd, via Kort St and Maree St, as an alternative to providing bus lanes in Voortrekker Rd and Durban Rd through the Bellville CBD.
- Extension of Hindle Rd to Melton Rd in Blue Downs.

Distributor and Feeder Routes

The same three Distributor routes proposed for TA2 have been included in TA3. These operate in mixed traffic as follows:

- D01 from Brackenfell to Tableview via Durbanville and Tygerberg Road (M13).
- D02 from Mitchells Plain to Cape Town CBD via Klipfontein Road, Main Road and Victoria Road.

- D03 from Hanover Park to Bellville via Turf Hall, Duinefontein and Robert Sobukwe roads.

Eighty six (86) of the 90 new feeder routes identified for the TA2 network have been retained in the TA3 network, as well as the existing feeder route provided for the MyCiTi phase 1 system.

Existing roadways

BRT Routes

The following roadways will need to be upgraded to include dedicated BRT lanes or to make provision for priority measures to ensure rapid bus movement in mixed traffic sections where dedicated lanes cannot be provided :

- (T10) Strand – Khayelitsha – Mitchell's Plain – Strandfontien – Steenberg – Westlake
    - o Strand Station terminus, Main Rd through Somerset West, Macassar Rd into Khayelitsha (M9), Steve Biko Rd, Mew Way, Spine Rd, AZ Berman Dr, 1st Ave (Mitchells Plain CBD Terminus), Wespoort Dr, Weltevreden Rd, Spine Rd, Strand-fontien Rd, Baden Powell Dr, New Link, Military Rd, Main Rd, Steenberg Rd, Bell Crescent terminus in Westlake;
- (T11) Wynberg – Lansdowne – Khayelitsha
    - o Wynberg Station access, Main Rd/Brodie Rd couplet, South Rd new carriage-way, Ottery Rd, Strandfontein Rd, Govan Mbeki Dr (M9),Jeff Masemola Rd, Spine Rd, Walter Sisulu Rd, Khayelitsha Station access, Steve Biko Rd, Govan Mbeki Rd, Oscar Mpetha Rd, Mew Way, Baden Powell Dr, Walter Sizulu Rd, Chris Hani Station terminus;
- (T12) Claremont – Lansdowne – Mitchell's Plain
    - o Claremont Station terminus, Stanhope Rd, Imam Haron Rd, Chichester Rd, Doncaster Rd, Race Course Rd, Turfhall Rd, Jan Smuts Dr, Govan Mbeki Dr (M9), Jeff Masemola Rd, Stock Rd, AZ Berman Dr, Wespoort Dr, 1st Ave, Mitch-ell's Plain CBD Terminus, Imperial St, AZ Berman Dr, Kilimanjaro St, Yellowwood St, Kapteinsklip Station terminus;
- (T13) Mitchell's Plain – Symphony Way – Bellville – Durbanville
    - o Mitchell's Plain CBD Terminus, 1st Ave, Wespoort Dr, New Eisleben Rd, Jeff Masemola Rd, Symphony Way, Robert Sobukwe Rd, Belrail Rd, Bellville PT In-terchange, Charl Malan St, Voortrekker Rd, Durban Rd (alternatively new link via Kort St extension), Willie Van Schoor (northwards)/ Durban Rd (southwards), Durbanville Ave, Main Rd, Wellington Rd, New Street Terminus;
- (T14) Westlake - Retreat – Hanover Park – Epping – Parow – Bellville
    - o Bell Crescent terminus, Steenberg Rd, Main Rd, Station Rd, Concert Blvd, Re-treat Rd, 5th Ave, Strandfontien Rd, Govan Mbeki Dr, Hanover Park Ave, Turfhall Rd, Vanguard Dr, Viking Way, Avonwood Ave, Francie van Zijl Dr, Mike Pienaar Rd, Voortrekker Rd, Charl Malan St, Bellville Terminus;
- (T15) Strandfontien – Pelikan Park – Athlone – Pinelands – Maitland – CBD
    - o Spine Rd terminus, Strandfontien Rd, Jan Smuts Dr, Prestige Dr extension, new viaduct over rail lines, link to Phase 1A busway along south side of N1;
- (T16) Eersterivier – Blue Downs – Delft – Parow – Monte Vista –Bothasig – Parklands – Sandown

- Eersterivier Station, Bosman St (westwards)/ Stasie Rd (eastward), Van Reibeeck Rd, Forest Dr, Melton Rd, Hindle Rd, Symphony Way, Stellenbosch Arterial, 35th Ave, Jan Van Riebeeck Dr, Giel Basson Dr, new road over N7, Potsdam Rd, new road link to Sandown Rd, interface with MyCiti Phase 1 at Sandown Rd Station;

- (T17) Khayelitsha – Klipfontein – Epping – Maitland – Century City
    - Khayelitsha Station, Steve Biko Dr, Mew Way, Jeff Masemola Rd, New Eisleben Rd, Klipfontein Rd, Borcherds Quarry Rd, Robert Sobukwe Rd, Valhalla Drive, Nigeria Way (a new road south of Epping Industrial), Jan Smuts Drive, Prestige Drive extension (viaduct over rail lines), new busway along south side of N1 into Sable Rd, Ratanga Rd, Century Blvd, Bosmansdam Rd, Montague Dve, Koeberg Rd, Omuramba Rd, Ratanga Rd terminus;
- (T19) Wallacedene – Durbanville – Bellville – Parow – Century City
    - Bloekombos Station, Old Paarl Road, Van Riebeeck St, Langeberg Rd, Wellington Rd, Durbanville Ave, Durban Rd, Frans Conradie Dr, new road through Wingfield to Sable Rd, Ratanga Rd terminus station.

Facilities

BRT Terminals

Each of the BRT routes will require a closed terminal station at either end of the route at which space should be provided for buses to wait for departure time (lay-over) before approaching the loading platform and provision must also be made for the vehicles to turn around and change direction. In addition, sufficient feeder drop-off and loading platforms will need to be provided. Table 5-1 is a provisional list of such facilities, including intermediate transfer terminals where several trunk routes, including rail, may interface:

Table 5-1 - BRT Terminals

Name of Terminal	Location	Interface with Rail	Rapid bus lines	Lay-over	Feeder lines
Strand Station	Main Road, Somerset West	Yes	T10	Yes	F01, F02, F03
Westlake	Bell Crescent, Westlake	No	T10, T14	Yes	F20,F56
Wynberg	Morom Road, Wynberg	Yes	T11	Yes	F12, F19, F21, F23
Khayelitsha	Khayelitsha Mall, Walter Sisulu Rd,	Yes	T10, T11,	Yes	F05, F09

Name of Terminal	Location	Interface with Rail	Rapid bus lines	Lay-over	Feeder lines
Claremont	Newry St, Claremont	Yes	T12	Yes	F12, F24
Mitchell's Plain	1st Avenue/Alpha St.	Yes	T10, T11,	Yes	F10, F11
Bellville PTI	Charl Malan Street	Yes	T13, T14	Yes	F36, F38, F39, F41, F43, F50
Durbanville	New Street, Durbanville	No	T13	Yes	D01, F40, F44
Retreat Station	Station Way, Retreat	Yes	T14	Yes	F21, F22
Strandfontien	Cnr Spine Road and Trafalgar Dr	No	T10, T15	Yes	F14
Eersterivier Station	Stasie Road Eersterivier	Yes	T16	Yes	F06
Sandown Rd	R27/Sandown Road East	No	T03, T04,	Yes	215,216
Century City	Ratanga Road	No	T17,T19	Yes	250,251
Bloekombos Station	Wallacedene	Yes	T19	Yes	-

Closed route stations

Each BRT route will require stations that are located in the median, strategically spaced to support the land use, pedestrian desire lines and interfaces with feeder routes. The locations of these are based on an average spacing of 800m but each station site was selected based on the road configuration, intersections and adjacent land use.

Open stops

In some areas it is not possible, without drastic property acquisition, to incorporate closed median stations into the road reserve. In these areas the BRT buses will operate on the left side of the roadway, with appropriate priority measures at intersections, and will load and disembark passengers at kerbside stops. The buses on the routes where this is the case, will be fitted with fare validators at the left hand door adjacent to the driver.

Feeder stops

For modelling and costing purposes an average spacing of 500m between feeder stops has been used.

5.5.3 Services

Rail

It is assumed that the hours of operation for the commuter rail service will be the same as for the MyCiti bus service to ensure integration of services, namely 18 hours per day from 04:00 to 22:00. However, this can be reduced to 16 hours if the results of the demand and operational cost modelling show that large deficits are caused by very low passenger utilisation in the early and late off-peak periods.

For the 2032 demand model it is assumed that all the existing train sets will have been replaced by the new PRASA rolling stock which is currently being manufactured and will be delivered to replace existing old train sets over a 10 year period commencing in 2016. Information obtained from PRASA indicates that the new 12 coach train sets will have a maximum passenger capacity of 2,430 for Metro class.

Road

BRT

Hours of operation

For the 2032 demand and cost modelling of TA3, all routes were assumed to operate between the hours of 04:00 and 22:00 (18hrs) 7 days per week, but a reduced frequency is assumed on weekends for the cost modelling.

Types of vehicle

The 2032 demand modelling was done with the following vehicle sizes for the different types of services:

- Trunk routes – 18m low floor articulated buses – 110 passenger capacity,
- Distributor routes – 12m low entry buses – 80 passenger capacity,
- Feeder routes – 9m low entry buses – 45 passenger capacity.

All these bus types will have doors on both sides of the vehicles so that they can serve passengers at either left side open stops are right side closed median stations.

Headways

An initial headway of 5 minutes was used in the 2032 peak hour model for all scheduled trunk, distributor and feeder services. Depending on the resulting demand on each route, the model determined the headway required to serve the calculated peak hour passenger with the specified vehicle size for each route.

If the headway required to serve the peak hour passenger demand on trunk routes is calculated by the model to be less than 90 seconds, double platform median closed stations will have to be provided for more than one bus to stop simultaneously, to prevent buses queuing. Passing lanes will also need to be provided at all stations.

If the passenger demand on feeder routes indicates that headways of 5 minutes are not sufficient with a 9m bus, a 12m bus will then be used on this route.

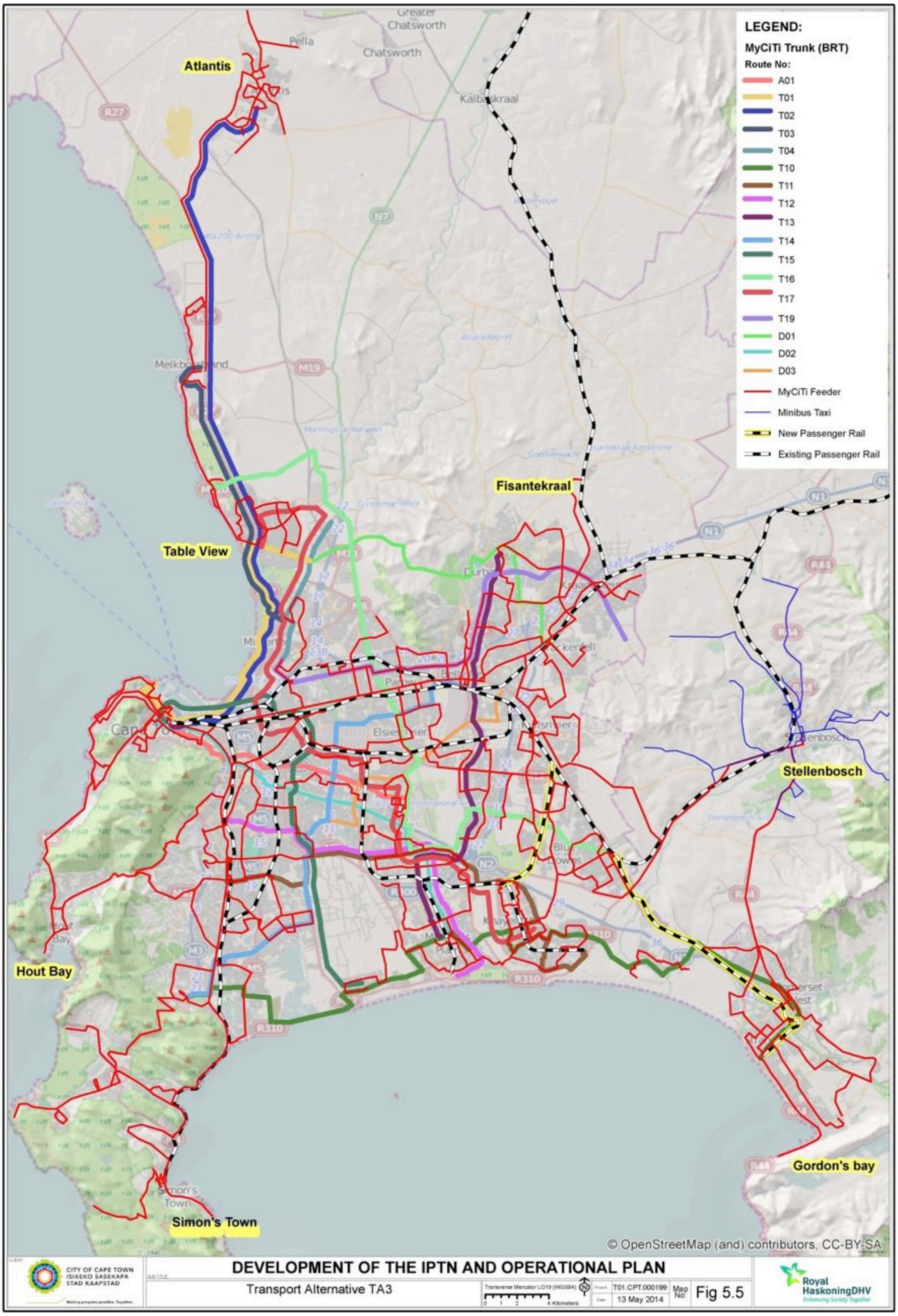


Figure 5-5: Transport Alternative TA3

5.6 Transport Network Alternative Four (TA4)

5.6.1 Introduction

The TA4 alternative was prepared after analysing the results of the 2032 peak hour passenger demand modelling for TA2 and TA3 and after examining the annual operating deficit which was determined by the cost modelling of these two alternatives. The cost modelling is described in chapter 8 of this report. A map of the TA4 network is shown in Figure 5-6.

The assumptions used in preparing TA4 were as follows:

- If a rail line has a modelled demand of less than 10 000 passengers per direction in the peak hour in 2032, this demand should be served by BRT. The model output in this regard indicates that the Atlantis and Fisantekraal lines do not need to be upgraded for commuter rail services by 2032.
- If a rail line has a peak hour passenger demand of between 10 000 and 20 000 per direction in the 2032 model, a phased approach should be applied, with a BRT service being provided initially and a rail service introduced later when the demand exceeds 10 000 peak hour passengers. This is applicable in the corridor between Khayelitsha and Somerset West, where the TA2 model indicates a peak hour demand of about 15 000 on the Chris Hani line extension in 2032.
- If a BRT trunk route has a modelled peak hour demand of less than 1 000 passengers in the peak direction in 2032, this route can function as a distributor/feeder or “trunk extension” operating in mixed traffic, with priority measures provided at road intersections to minimise the delay from traffic congestion.
- The operating deficit shown by the cost modelling of TA2 and TA3 is reduced in TA4 by replacing loss-making scheduled feeder services, which are operated with 9m buses in TA2 and TA3, with unscheduled “on-demand” services operated by minibus taxis.

5.6.2 Infrastructure

Rail

The only new rail line included in the TA4 alternative is the Blue Downs line between Nolungile and Kuilsriver stations. This line is forecast to carry about 26 000 passengers in one direction in the 2032 peak hour model, which will require a double track. Three stations are proposed along the new line, at Mfuleni, Blue Downs and Wimbledon.

The Chris Hani line extension which was included in TA2 and showed about 15 000 passengers in one direction in 2032 has been excluded from TA4 due to the uncertainty about the proposed large industrial development east of Macassar. A BRT route (T10) along Macassar Road has been included in TA4 to provide for the initial passenger demand until the threshold of 10 000 peak hour passengers is reached for the introduction of a rail service. It is important therefore to proclaim a rail reserve for the future extension of the Chris Hani line through Macassar to Firgrove Station which is on the Eersterivier-Strand line.

An alternative strategy for this corridor, which was mentioned as a possibility in the PRASA Strategic Plan (2012) is to provide a light rail transit (LRT) system instead of extending the heavy rail line from Chris Hani Station. Although a LRT system will probably cost more than a BRT system, it should be able to carry about 15 000 passengers per hour per direction.

Road
All the BRT trunk routes from TA3 have been included in TA4 with slight amendments as follows:

- T10 (Westlake – Strand) which had its eastern end terminus at Strand Station in TA3 has been extended to Gordons Bay to save passengers having to transfer to a feeder vehicle. This is also more cost beneficial for the City because the trunk bus would take too long to make a return trip to Khayelitsha to get enough passengers at the end of the morning peak period to make another trip to Strand viable. It is more efficient for the trunk bus to fulfil a feeder role at the end of the peak, which saves the cost of providing an additional feeder vehicle for the peak period.
- The western terminus of T10 has been changed from Westlake to Retreat Station because more passengers are transferring from T10 to T14 at Main Road to go northwards to Retreat, than the number of passengers continuing westwards along Steenberg Road to Westlake.
- T11 (Wynberg – Khayelitsha). The southern end of the route in Khayelitsha along Oscar Mpetha Rd, Mew Way and Baden Powell Drive to the terminus at Chris Hani Station will operate in mixed traffic because the bus passenger volumes and the road traffic volumes are low enough not to warrant road widening for dedicated bus lanes.
- T12 (Claremont – Mitchells Plain). The southern end of T12 in Mitchells Plain has relatively low bus passenger and traffic volumes along AZ Berman Drive (south of Spine Road), Kilimanjaro St and Yellowwood Street, which means that dedicated bus lanes are not needed on these roads.
- T13 (Mitchells Plain – Symphony Way – Durbanville). There are no changes required for this route from TA3 to TA4.
- T14 (Westlake – Bellville). The section of this route which used the N7 between Turfhall Road and Viking Way in TA3 was changed in TA4 because of the future planning to upgrade this section of the N7 to freeway standards, which would make access to median busway stations difficult and require long pedestrian bridges and ramps. The amended route is from Turfhall Rd into Pooke Rd and Hazel Rd, then along Klipfontein Rd, Duinefontein Rd and Valhalla Drive into Viking Way, from where it continues on the previous alignment in TA3 to the terminus at Bellville Station.
- T15, T16, T17 and T19 all remain the same as described in TA3.

The three distributor routes (D01,D02,D03) and the 120 feeder routes all remain the same in TA4, but the type of service provided on some feeder routes changes, as discussed below.

5.6.3 Services

Rail
The same hours of operation for the rail services have been used in the 2032 demand and cost modelling for TA4 as in TA2 and TA3, namely 04:00 to 22:00, with the frequency of service being based on the passenger demand per line and providing for a possible headway of 3 minutes in the peak periods and a desirable headway of 20 minutes in the off peak periods.

It has also been assumed that all current train sets will have been replaced by new rolling stock by 2032 and the fleet will have been increased to serve the expected growth in rail passenger demand.

Road

The operational cost modelling of the TA2 and TA3 alternatives, when expanded from the 2032 peak hour demand to an annual cost, using factors obtained from the Phase 1A MyCiTi operation, indicates that the annual deficit will be more than twice the available subsidies from Treasury and the City for road based public transport.

In order to reduce this unaffordable deficit in the TA4 alternative, the loss-making feeder services which were operated with 9m MyCiTi buses in TA2 and TA3 at 5 minute headways in the peak periods and 20 minutes in the off-peak periods, have been replaced by unscheduled minibus taxis which are assumed to operate without a deficit. This implies that they will only operate when there is sufficient passenger demand to cover their cost of operating on a feeder route. The cost modelling showed that 80% of the feeder routes in TA2 and TA3 will need to be allocated to unscheduled minibus taxis in order to reduce the road-based operating deficit to the level of the projected Treasury and City combined subsidy allocation.

TA4 is thus essentially a hybrid between a scheduled trunk route service and a predominantly unscheduled feeder service, with only 20% of the feeder routes guaranteed to operate with a timetable and a fare system that is integrated with the trunk route services. This reduces the reliability of the system for passengers who need to use an unscheduled minibus feeder service to get to a trunk route. It also means that passengers will need to pay cash fares for the minibus taxi service and use a MyConnect card for the trunk service.

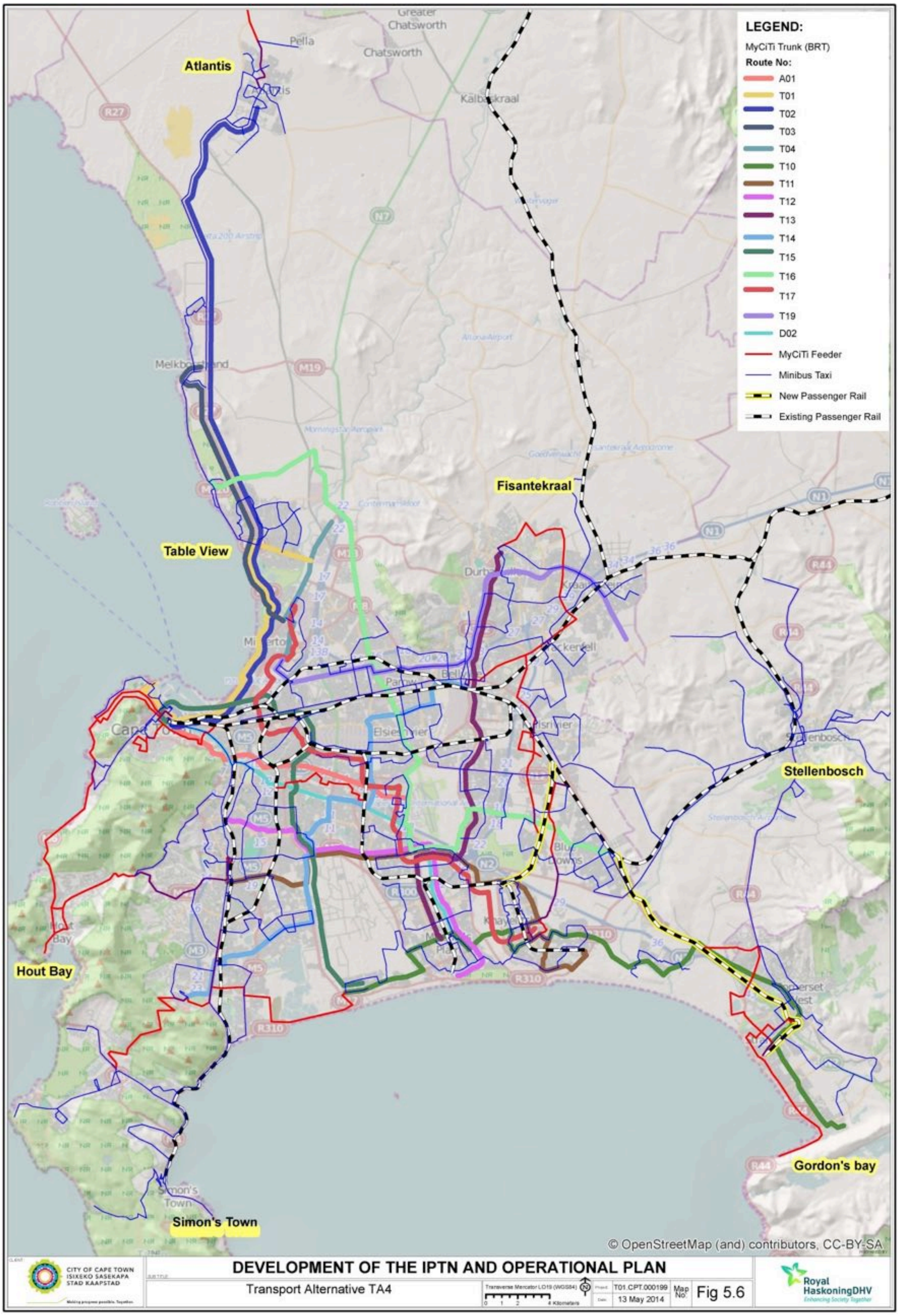


Figure 5-6: Transport Alternative TA4

5.7 Transport Network Alternative Five (TA5)

5.7.1 Introduction

Due to the difficulty of ensuring integration between unscheduled minibus taxi feeder services and the scheduled trunk services, it was decided to retain scheduled feeder services for alternative TA5 and to test the effect on the operating deficit of reducing the frequency of service for both trunk and feeder services from the levels used in TA3.

By limiting the provision of trunk BRT services to 90 second headways in the peak hour on busy routes where the model showed that a more frequent service than this was required to meet the demand, it was assumed that once all buses were running at their maximum load capacity, commuters who could not get on a full bus would be prepared to travel up to 30 minutes earlier or later than the peak hour. Spreading the peak hour demand in this way means that additional buses (and drivers) do not have to be acquired to satisfy a one hour excessively high demand period and then stand idle for the rest of the day. Better utilisation of the fleet is possible if the peak demand is spread evenly over 2 hours as this enables most buses to make two full trips during the extended peak period, whereas they currently achieve only one full trip in the peak direction in the peak hour. The cost modelling showed that the operating deficit was reduced by 34% as a result of spreading the peak demand over 2 hours by limiting the headway supplied to 90 seconds.

During the off-peak periods, if the demand on either trunk or feeder routes was less than 65% of the supplied capacity of vehicles running at the headway of 20 minutes used in TA3, it was found that by increasing the headway to 30 minutes, the same hourly passenger demand could be carried with 33% fewer vehicle kilometres of travel. However, the same number of off-peak vehicles and drivers would be required, so the saving would only be in the km running cost of the vehicles.

Although spreading the peak reduced the deficit significantly, it was still necessary to replace 20% of the loss making scheduled feeder buses with unscheduled minibus taxis, in order to reduce the deficit to the amount of the combined PTOG and PTNOG grants from Treasury. A map of the TA5 network is shown in Figure 5-7, which is only slightly different from the TA4 network in that fewer feeder routes are allocated to unscheduled minibus taxi services.

5.7.2 Infrastructure

Rail
The same rail infrastructure that was required for TA4 is assumed for TA5, namely the new Blue Downs double-track line with three stations on this line between Nolungile and Kuilsriver.

Road
The same trunk and feeder routes that were used in TA4 are assumed for TA5. The main difference resulting from limiting the headways to a minimum of 90 seconds in TA5 is that a single closed median platform is able to handle buses at this headway (with passing lanes for express buses) whereas in TA4 where headways of less than 90 seconds were required to accommodate the unconstrained peak hour demand, double platform stations are needed, with passing lanes.

5.7.3 Services

Rail
The 18 hour duration of rail services can be reduced to 16 hours if the first and last hours of the daily service have very low demand. The frequency of service is assumed to be provided according to the variation in demand throughout the day, with a minimum headway of 3 minutes between trains in the peak hours and a maximum headway of 20 minutes in off-peak periods.

Road
As explained in the introduction to TA5, the operating deficit has been reduced significantly from that shown in the other alternatives by limiting the supply of BRT services to 90 second headways in the peak periods to effect a spreading of the high peak hour demand so that buses are able to run full for at least two hours in each of the morning and afternoon peak periods.

During the off-peak periods, where the demand is less than 65% of the capacity provided by buses running at a headway of 20 minutes, this demand can be carried by buses running at a headway of 30 minutes, which will result in a 33% reduction in the vehicle running costs.

Although most of the feeder services are scheduled in this alternative, 20% of the feeder routes are allocated to unscheduled services. These unscheduled services are primarily on the Stellenbosch and Strand/Somerset West area and are indicated in Figure 5-7 below.

5.8 Capillary network

A public transport system is made up of a variety of modes. The transport network alternatives described above focus on the higher capacity modes to generate the IPTN. Any of these alternatives is assumed to be supported by lower-capacity modes such as local minibus taxi, metered taxi and even private transport trips which is in addition to non-motorised transport modes such as walking, cycling and pedicabs. These modes provide fine-grained capillary-type services that provide mobility for people typically travelling short trips to local destinations e.g. local minibus taxi trips; or for access to the higher-capacity public transport network, e.g. feed the feeders (and in specific instances the trunks), or for individual trip requirements for a direct trip to a specific destination e.g. metered taxi or Dial-a-Ride type services and for "last mile home" services. Similar to non-motorised transport these lower-capacity services are too fine-grained to be modelled and therefore these are not specifically referred to in the transport network alternatives.

In addition, the transport network alternatives provide 80% of the entire Cape Town population with access to the high-order Integrated Public Transport Network (IPTN) within 500m. It is assumed that the entire metropolitan population will have access to capillary modes, and therefore the 20% of the population not served by the high-order IPTN will be served by this capillary network of lower-capacity modes such as minibus taxi, metered taxi, etc. The capillary network of lower-capacity services is assumed to be applicable to any of the transport network alternatives and does not provide a difference between the transport network alternatives.

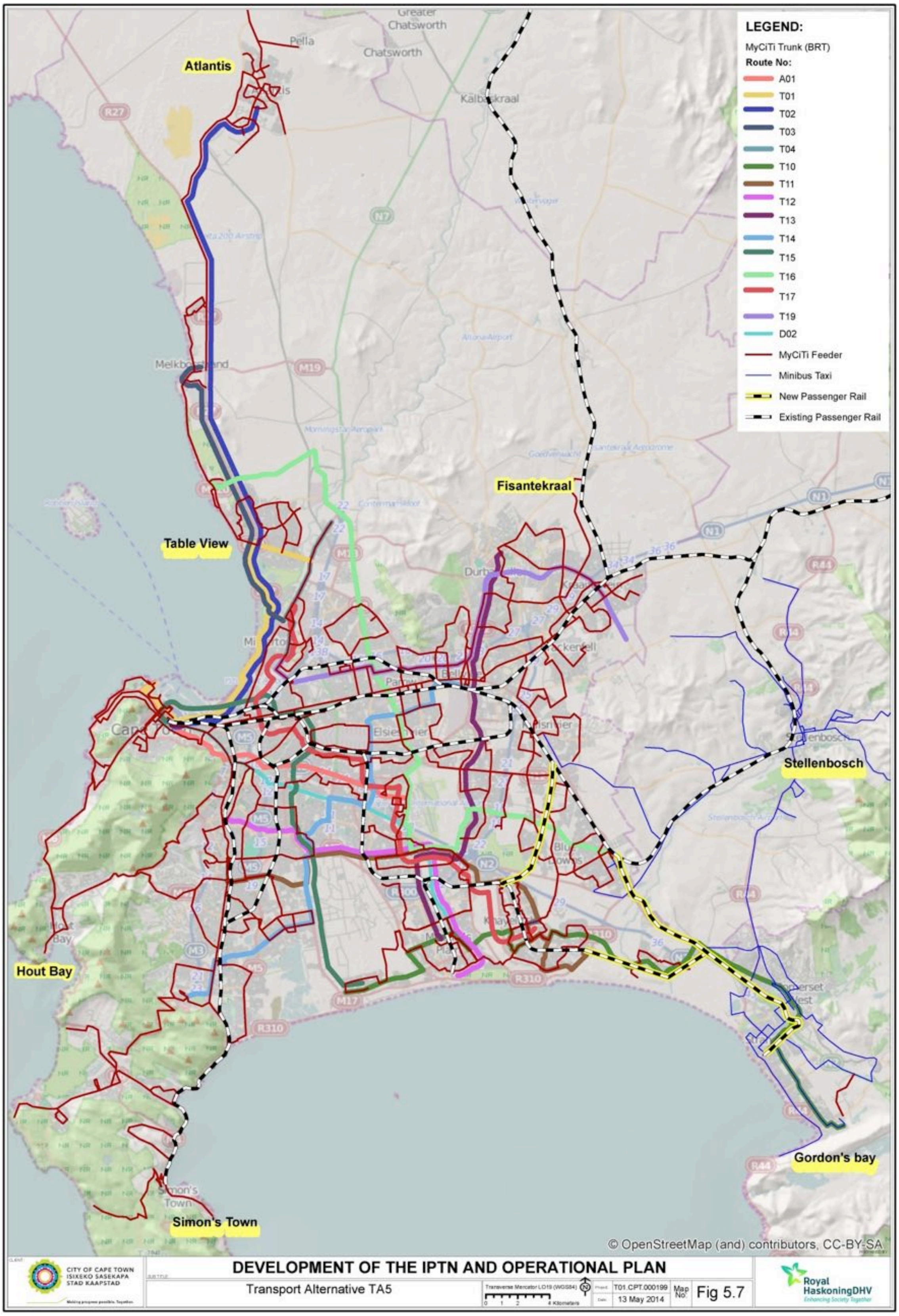


Figure 5-7: Transport Alternative TA5

6. Testing of IPTN alternatives

6.1 Introduction

Alternative Integrated Public Transport Networks were developed and tested against various future land use scenarios. The networks that were tested have been described in Chapter 5 and the various land use scenarios that were developed for a 20 year planning horizon are described in Chapter 4. As the base year in which this investigation commenced was 2012, it was decided to choose 2032 as the horizon year. The precise year is of little significance as the extent of development in terms of population, job creation and other aspects may realise earlier or later without significantly influencing the network itself, but only perhaps the implementation plan.

The land use scenario chosen as the basis for the comparison of the various network options was called Pragmatic TOD as it includes some movement away from the current trend of sprawl towards a more compact, densified City, but not as dramatic as the Comprehensive TOD. The preferred network, resulting from a multi criteria assessment of the performance of the alternatives, will be tested against the Comprehensive TOD as part of a sensitivity analysis to ascertain the extent of further transport cost savings that could be achieved through a more transport orientated land use development strategy.

The Transport Demand Model developed as part of this study was the tool used to determine the expected travel demand in terms of passengers and vehicles. The modelled output was used as input for the other analysis processes such as the economic, environmental and social impact assessments, operating cost calculations, determination of fleet required, station configuration and depot sizes. The model outputs, which include tables and plots of vehicle and passenger volumes per route and per mode, are presented and discussed in detail in a separate technical report on the modelling. This chapter will therefore only give a summary of the model outputs.

The demand model was developed for the peak hour only, as has been described in chapter 3. Daily and annual cost calculations were done by the careful use of expansion factors as discussed in chapter 8 on cost and revenue modelling.

6.2 Demand Modelling

6.2.1 Population and employment projections

It is projected that the population will grow from 4 104 994 in 2012 to 5 571 737 (36% growth) over 20 years, as explained in chapter 4.

Table 6-1 gives a breakdown of the population in various categories for 2012 and 2032 and shows the relative growth per category. It is important to note in the table that there is expected to be a reduction in the number of unemployed persons and housewives, resulting in a greater percentage of employed persons who will travel during the peak period in 2032.

Table 6-1: Expected Growth in Population per Category

Category	2013	2032 PTOD	Growth
Employed (full time)	1 222 256	2 046 104	67%
Employed (part time)	107 142	175 340	64%
Employed (self)	202 845	338 903	67%
Unemployed (not seeking work)	249 121	225 348	-10%
Unemployed (seeking work)	474 586	422 052	-11%
Employed (construction)	45 745	75 111	64%
Pensioner	511 297	700 621	37%
Student (Tertiary)	96 431	130 995	36%
Student (primary & secondary)	511 733	693 558	36%
Housewife	230 920	147 921	-36%
Less than 6y of age	452 917	615 785	36%
Total	**4 104 994**	**5 571 737**	**36%**

Table 6-2 below is a summary of the increase in employment per category over 20 years. It is expected that the number of employed persons (including tertiary students) will increase from 2 186 153 to 3 526 522 which represents an increase of 61% over 20 years. The exceptionally high percentage increases for workers in the community, construction, transport and recreation sectors is due to their low representation in the 2013 employment database.

Table 6-2: Expected Growth in Employment per Category

Category		2013	2032 PTOD	Growth
Business	Office	**412 541**	619 307	50%
Business	Retail	**170 848**	210 249	23%
Industrial	Manufacturing	**329 995**	443 822	34%
Industrial	Services	**114 971**	147 855	29%
Industrial	Warehouse	**274 411**	352 651	29%
Community	Community	**80 953**	188 366	133%
Community	Construction	**133 717**	290 816	117%

Other	Transport	**7 981**	155 209	1845%
Other	Recreation	**12 379**	221 806	1692%
Other	Agriculture	**323**	353	9%
Education	Personnel	**39 869**	71 535	79%
Education	Students	**608 164**	824 553	36%
Total		**2 186 153**	**3 526 522**	**61**

6.2.2 Road network assumptions

The future additions to the road network included in the 2032 demand model were determined by selecting those parts of the ultimate long term network that were most likely to be constructed by 2032. Newly developed areas were provided access by selecting appropriate access roads. The additional road sections amounted to 1078 lane km of new roads and are indicated in red in Figure 6-1 below.

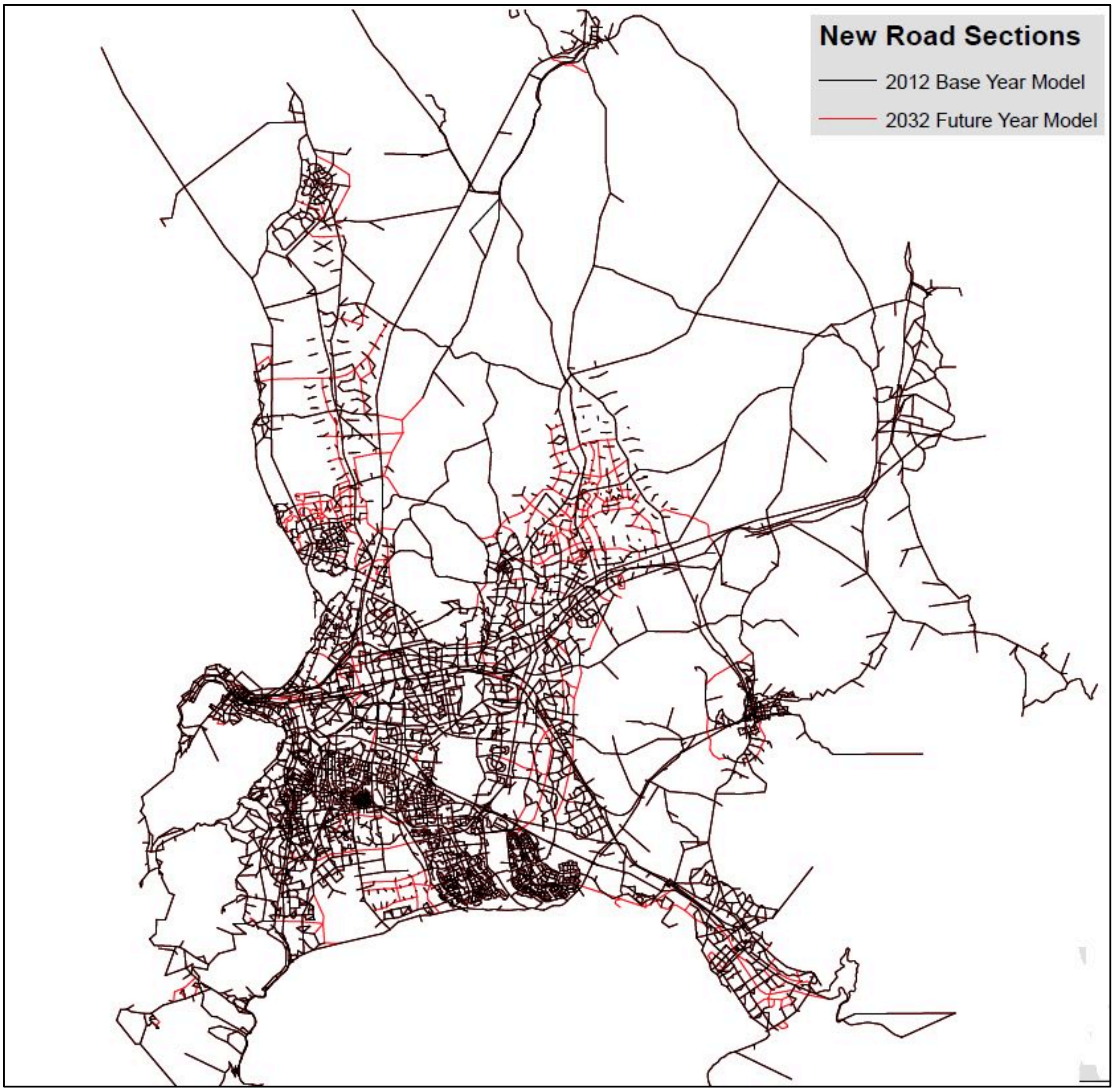


Figure 6-1: Additional Roads in 2032 Transport Demand Model

6.2.3 Fare structure and levels.

The fare structure for all modes was kept constant over the 20 year period for purposes of the travel demand modelling, thus assuming that the relative attractiveness of the different modes in terms of cost to the users stays the same. The actual fares incorporated in the model are provided in

Table 6-3

Table 6-3: Public Transport fares used for modelling purposes

2012 fares in Rand by mode					
Mode					
Rail		**Contract Bus**		**MyCiTi***	**Minibus Taxi****
Distance (km)	**Fare**	**Distance (km)**	**Fare**	**Fare**	**Fare**
7	R 6.00	8	R 5.80	R 6.57	R 7.41
16	R 6.50	12	R 6.70	R 7.12	R 8.08
27	R 7.50	15	R 7.60	R 7.54	R 8.59
37	R 8.60	21	R 8.40	R 8.37	R 9.60
132	R 11.00	32	R 9.10	R 9.89	R 11.46
196	R 16.00	40	R 9.50	R 11.00	R 12.80
		55	R 10.40	R 13.07	R 15.33
		60	R 14.40	R 13.76	R 16.18
*Based on the formula 5.46 + 0.1384 times distance					
**Based on the formula 6.06 + 0.1686 times distance					

6.2.4 *Speeds and headways for public transport modes*

The speeds and headways differed for the various lines and modes. The average speed and headway for each public transport mode in the 2032 model is shown in Table 6-4 below.

Table 6-4: Average speed and headway per mode in 2032 peak hour

Attribute	MyCiTi Trunk	MyCiTi Feeder	Contracted Bus	Minibus Taxi	Rail
Average speed (km/hr)	22	14	17	20	24
Average headway (min)	6	12	27	24	9

Note that the model uses the input headway and vehicle size to calculate the line capacity and waiting time, but does not restrict the demand to this headway. The demand can therefore exceed the capacity, which occurs for both private and public transport modes.

6.2.5 *Passenger demand forecasts*

Four future (2032) public transport network alternatives (TA1 to TA4) were tested with the demand model and the modal split results compared to the 2013 base year are given in Table 6-5. It is expected that the number of person trips in the morning peak period will increase from 1 402 520 to 2 054 394 which represents an increase of 46% in person trips. The higher increase in person trips compared to the increase in population (36%) is due to the expected reduction in the current unemployment rate.

A number of important observations can be made when the proportions of trips for the different public transport alternatives are compared. The first is that in TA1, which represents "business as usual" the proportion of private vehicle users (0.53) does not reduce compared to the base year. In TA2 the MyCiTi BRT and feeders replace most of the contracted bus and minibus taxi services and the rail share increases from 0.13 in 2013 to 0.20 in 2032 with a small increase in private vehicle usage from 0.53 to 0.55. Alternative TA3 resulted in a reduction in private vehicle usage from 0.53 (2013) to 0.47. Alternative TA4, which incorporates the minibus taxi mode results in a reduction in the market share of private vehicles to 0.48 (but not as much as TA3). The important conclusion is that if public transport provides a viable option to private vehicle usage and the coverage of the public transport system is increased, the market share of public transport will increase.

It must be noted that TA5, which assumes that the high peak hour demand on the BRT mode in TA3 can be spread evenly over a two hour period by limiting the headways to 90 seconds, was not able to be modelled due to the fact that the demand model is for the peak hour situation only and cannot determine what will happen outside this hour to verify the assumption of peak spreading. However, this assumption has been used in the spreadsheet based cost modelling (chapter 8) and in the evaluation of the alternatives (chapter 9).

Table 6-5: Morning Peak Period Modal Split Results

Category	**2013**		**2032 TA1**		**2032 TA2**		**2032 TA3**		**2032 TA4**	
	Trips	Prop	Trips	Prop	Trips	Prop	Trips	Prop	Trips	Prop
Walk	111 408	0.08	103 332	0.05	102 795	0.05	102 795	0.05	102 795	0.05
Private Vehicle	742 785	0.53	1 096 033	0.53	1129 504	0.55	975 189	0.47	989 789	0.48
Minibus Taxi	213 907	0.15	331 685	0.16	1 238	0.00	5 068	0.00	115 765	0.06
Contracted Bus	148 741	0.11	213 513	0.10	1 238	0.00	1 244	0.00	1 242	0.00
MyCiTi	1 664	0.00	39 936	0.02	414 930	0.20	661 254	0.32	542 027	0.26
Rail	184	0.1	269 430	0.1	404 845	0.2	308 999	0.1	302 930	0.1

	015	3		3		0		5		5
Total	**1 402 520**		**2 053 929**		**2 054 550**		**2 054 549**		**2 054 548**	

6.3 Assumptions and their limitations

The calibrated base year model was used to analyse the future scenario. This model was developed based on the Base Year Household Survey Data and traffic counts and reflects the base year patterns and behaviour to an acceptable degree of accuracy as shown in the Modelling Report. For the analysis of the future scenarios it was assumed that the following will stay constant:

- Trip Generation Rates
- Trip Distribution Pattern
- Modal split parameters
- Traveling cost (private and public) By doing this the relative attractiveness of the different modes in terms of monitory values stays the same
- The volume delay functions (It was found that the volume delay functions allocate too high speeds on the lower order roads)

The major changes incorporated in the future scenarios are:

- Population and employment
- Private Network (road upgrading and new roads)
- Public Transport Routes

The expected future population and employment has by far the highest uncertainty, both in terms of the number of people and workers as well as the location thereof. Both the number of persons/workers and the location of persons/workers have a direct impact on the proposed private network upgrades and public transport roads to be tested. Any combinations of the land use scenarios that were tested could materialize in future. It is therefore important to monitor how the City of Cape Town develops and re-evaluate the proposals as and when needed.

The number of future trips was calculated by means of the trip generation rates and changes only as a result of the number of people and workers.

The trip distribution is affected by the location of people and workers relatively towards one another. A different location pattern will therefore result in a different distribution pattern. The distribution pattern is also influenced by new roads which can increase the relative attractiveness of certain areas due to shorter access time.

The modal split is affected by the public transport availability and routes as well as the in vehicle travel time (which is dependent on the level of congestion), walk time, wait time and number of transfer. The walk time is a result of the coverage of the proposed public transport network while the wait time and number of transfers are indications of the quality of the service. The costs were not changed as mentioned.

7. Demand modelling results of IPTN alternatives

7.1 Introduction and process

Several different integrated public transport networks were developed as described in chapter 5. These include a base 2032 network that was developed as a "do minimum" alternative and was used to compare the performance, costs and benefits of the other networks. Four additional networks were developed, called TA2, TA3, TA4 and TA5. This chapter provides the demand model outputs that were obtained and provides initial conclusions.

The following was taken into account in the development of TA2 and TA3 to serve the demand

- Existing and future OD matrices (volumes and desire lines)
- Existing services (current bus and minibus taxi routes)
- Coverage (Accessibility and OD pair coverage)
- 80% of population within 500m of a PT stop / station
- Technologies required
- Future road network the same for all alternatives (network most likely to be built in 2032)

In the development of TA4 and TA5, the "best" features of TA2 and TA3 were selected and combined with financial sustainability considerations (e.g. involvement of minibus taxis, reducing the level of services and peak demand spreading).

It must be remembered that all these results respond to a 2032 travel demand created by the pragmatic TOD land use scenario and may change when tested for other land use scenarios.

7.2 Demand Model Results

7.2.1 Network Alternative TA1

The output from the 2032 travel demand is shown on a set of maps that illustrate the vehicle volumes on the road network in the peak hour and separate Figures for each of the public transport modes showing the passengers per hour on each route. Different colours are used to indicate volume of vehicles on the roads, as shown in Figure 7-1, and to illustrate passenger load factors on each of the line sections for the public transport modes in the subsequent figures.

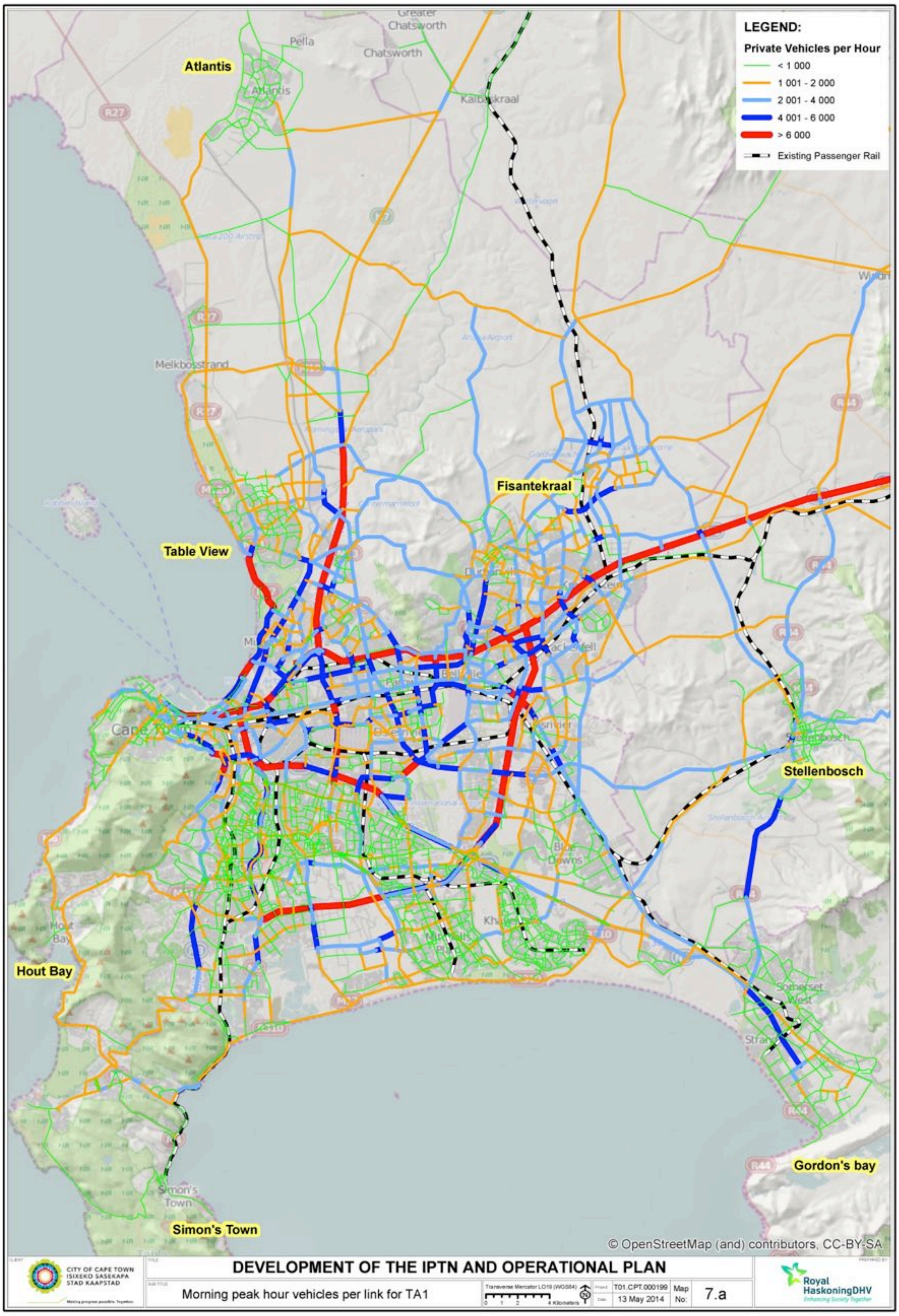


Figure 7-1: TA1 Network showing morning peak hour vehicle volumes for 2032

The peak hour private vehicle travel demand was assigned by the model to the road network. The various colours indicate peak hour volumes of traffic expected in 2032. From the figure above it can be seen that most of the freeways are shown in red which indicates that they carry more than 6000 vehicle in the peak hour, which is roughly the capacity of a six lane highway. Most of the arterial network links are coloured light and dark blue which also means that serious congestion will arise if the network capacity is not increased. Those links of the class 3 roads coloured orange are also carrying high volumes of traffic.

It must be noted that the colours on the road network in Figure 7-1 are not necessarily a measure of the volume/capacity ratio. They only show peak hour volumes. Detailed volume to capacity ratio information on each road link is presented in the detailed modelling report.

The morning peak hour rail passenger volumes are shown for TA1 in the figures below. The bandwidth indicates the hourly passenger volumes on the different links and the colours indicate the load factors on the different links as indicated in the legend on Figure 7-2.

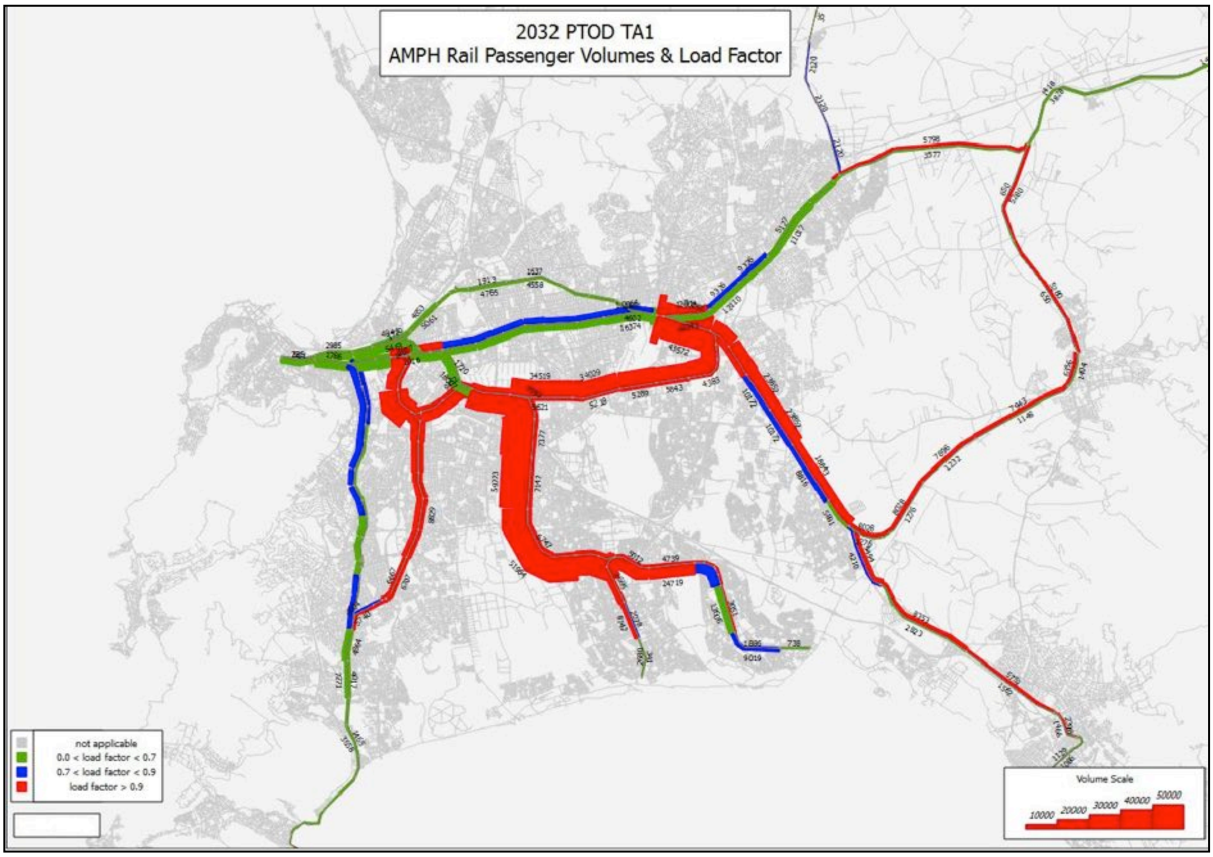


Figure 7-2: TA1 2032 Morning peak hour rail passenger volumes and load factors

As can be seen in the figure, the highest volume occurs on the rail section from Nyanga to Bonteheuwel station with about 48 000 passengers. As a result of the rail modernisation project that has been assumed to have been implemented by 2032 some spare capacity has been created on the links towards the west and north. As the Stellenbosch and Strand lines are single track, capacity problems are expected by 2032 on these lines.

The 2032 peak hour passenger volumes estimated to use unscheduled Minibus Taxi services are indicated in Figure 7-3 below.

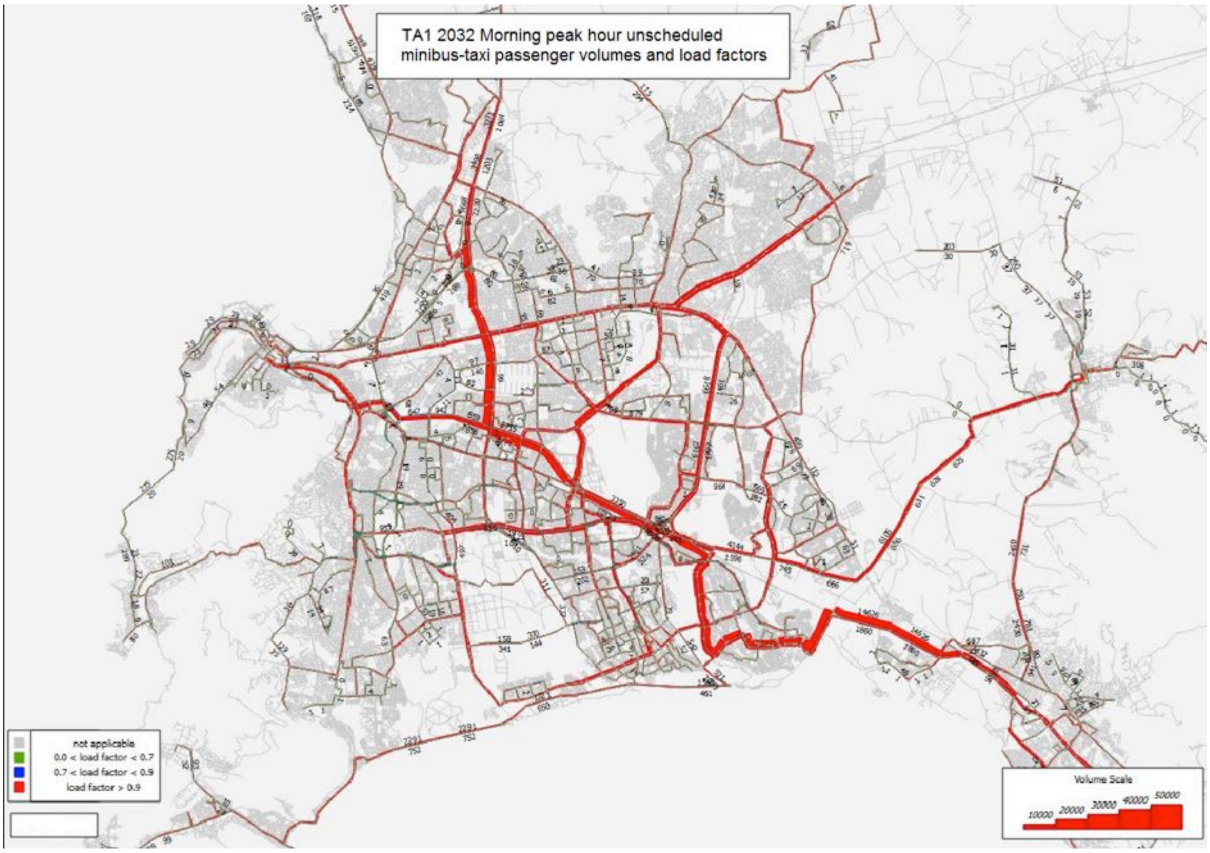


Figure 7-3: TA1 2032 Morning peak hour unscheduled minibus-taxi passenger volumes and load factors

The demand model shows relatively high minibus-taxi usage from Khayelitsha towards the north and especially east towards Strand. This is a result of substantial development expected in the Somerset West/Strand area. Less traffic is expected towards the CBD mainly because of the improved rail service and little additional development expected in the CBD according to the PTOD land use scenario.

The current contracted bus services (GABS and Sibanye) have been assumed to continue in the TA1 network alternative and the expected passengers in the 2032 peak hour on these services is shown in Figure 7-4.

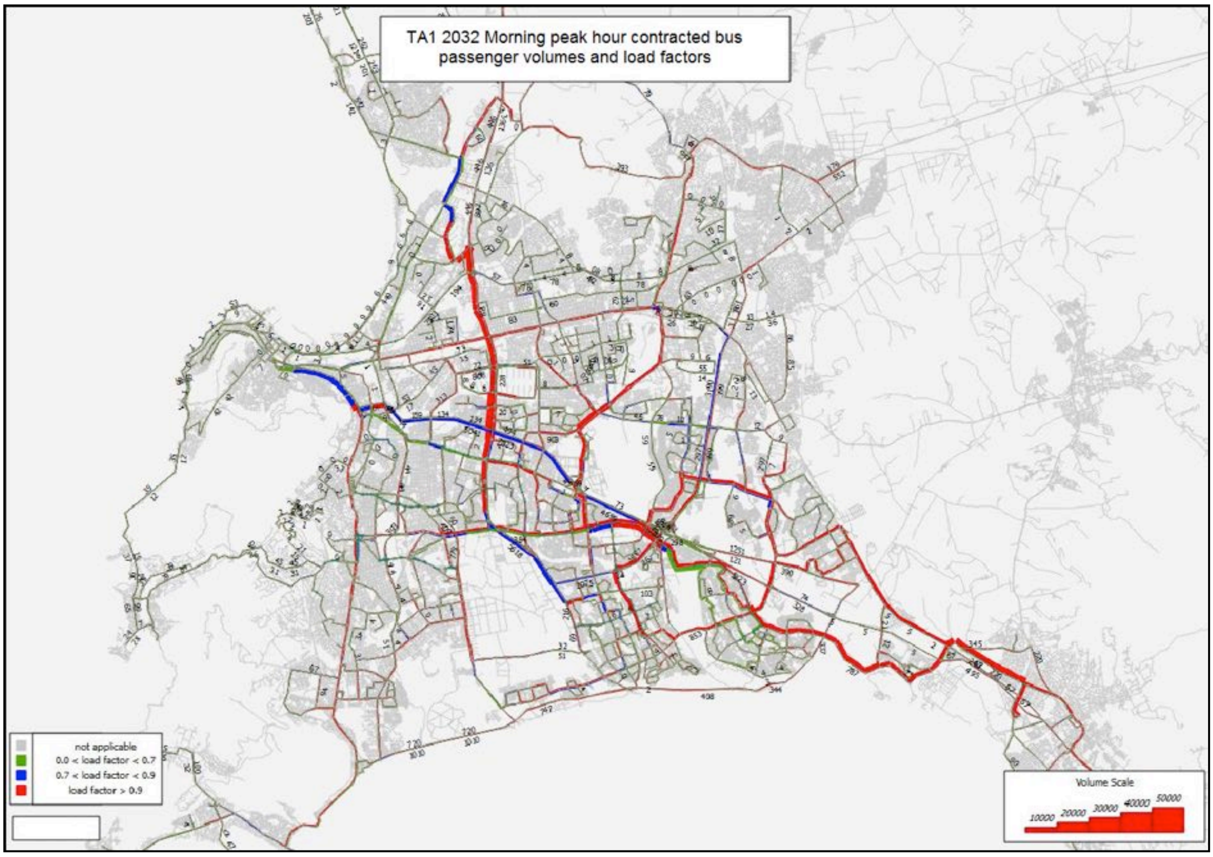


Figure 7-4: TA1 2032 Morning peak hour contracted bus passenger volumes and load factors

It can be noted from the above figure that as with the unscheduled minibus taxi services, there is an expected shift back to the rail mode on routes to the CBD. There are increases in usage from the Crossroads area towards the north and relatively high passenger volumes from Khayelitsha, Delft and Blue Downs to new employment in Somerset West/ Strand.

7.2.2 Network Alternative TA2

This network expansion included mostly new rail links, but also some new BRT routes. The exact extent of the new routes and services is described in chapter 5. The private vehicles assigned to the road network for alternative TA2 is shown in Figure 7-5.

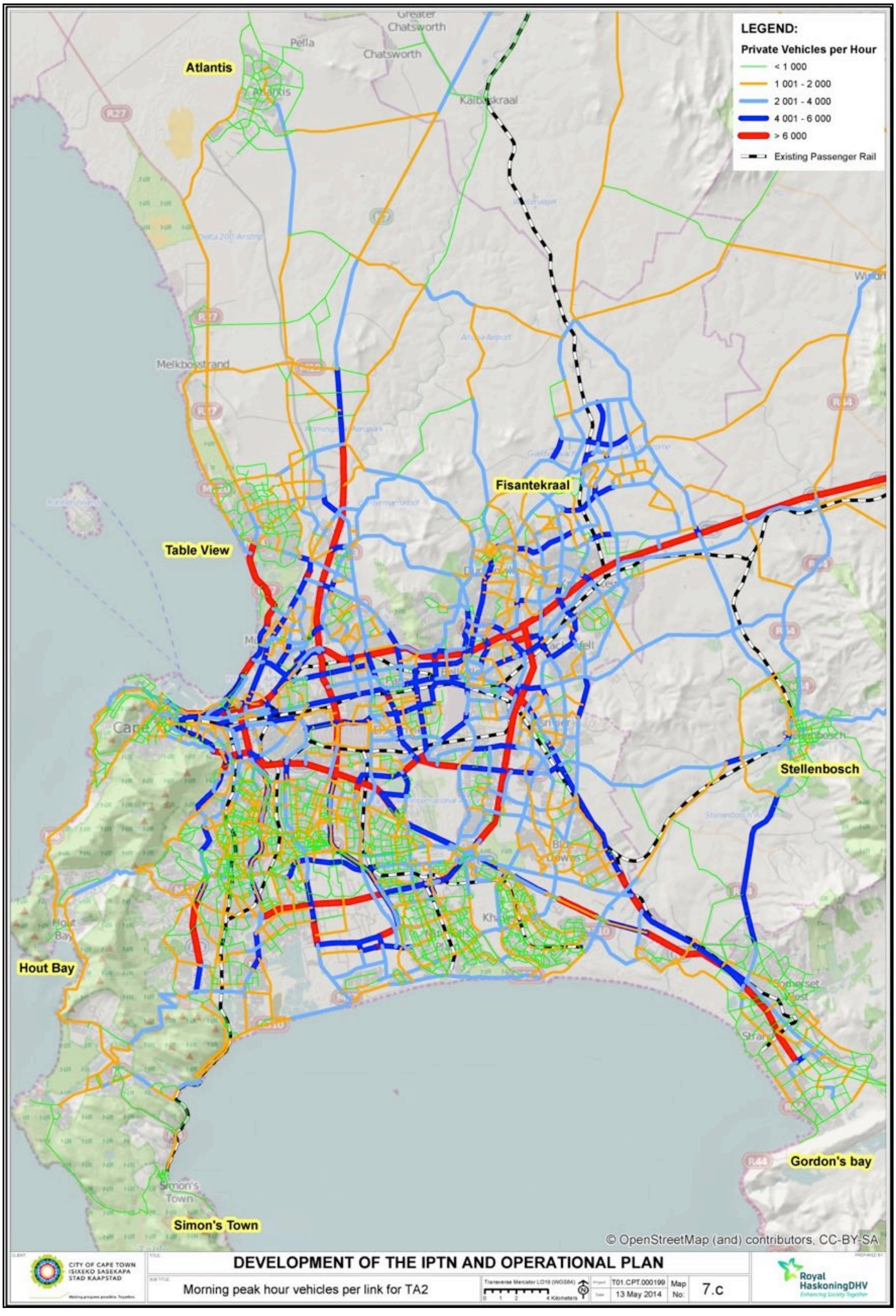


Figure 7-5: TA2 Peak hour private vehicles on the road network in 2032

The road network usage when compared to the TA1 network shows similar vehicle volumes for the peak hour, except that there is more private car traffic on the roads towards Somerset West and Strand. This indicates that previous users of buses and minibus taxis in TA1 from Delft, Blue Downs and Mfuleni will not all shift to the new rail link, but some will rather use private transport because it is quicker and does not require a transfer from a feeder to the rail.

The morning peak hour passenger volumes for TA2 for each of the public transport modes are shown in figures below. The network includes the Atlantis commuter rail line, doubling of the Fisantekraal line, the Blue Downs line and the Chris Hani rail extension to Firgrove station. The bandwidth indicates the hourly passenger volumes on the different links and the colours indicate the load factors of the different links. The rail passengers are shown in Figure 7-6.

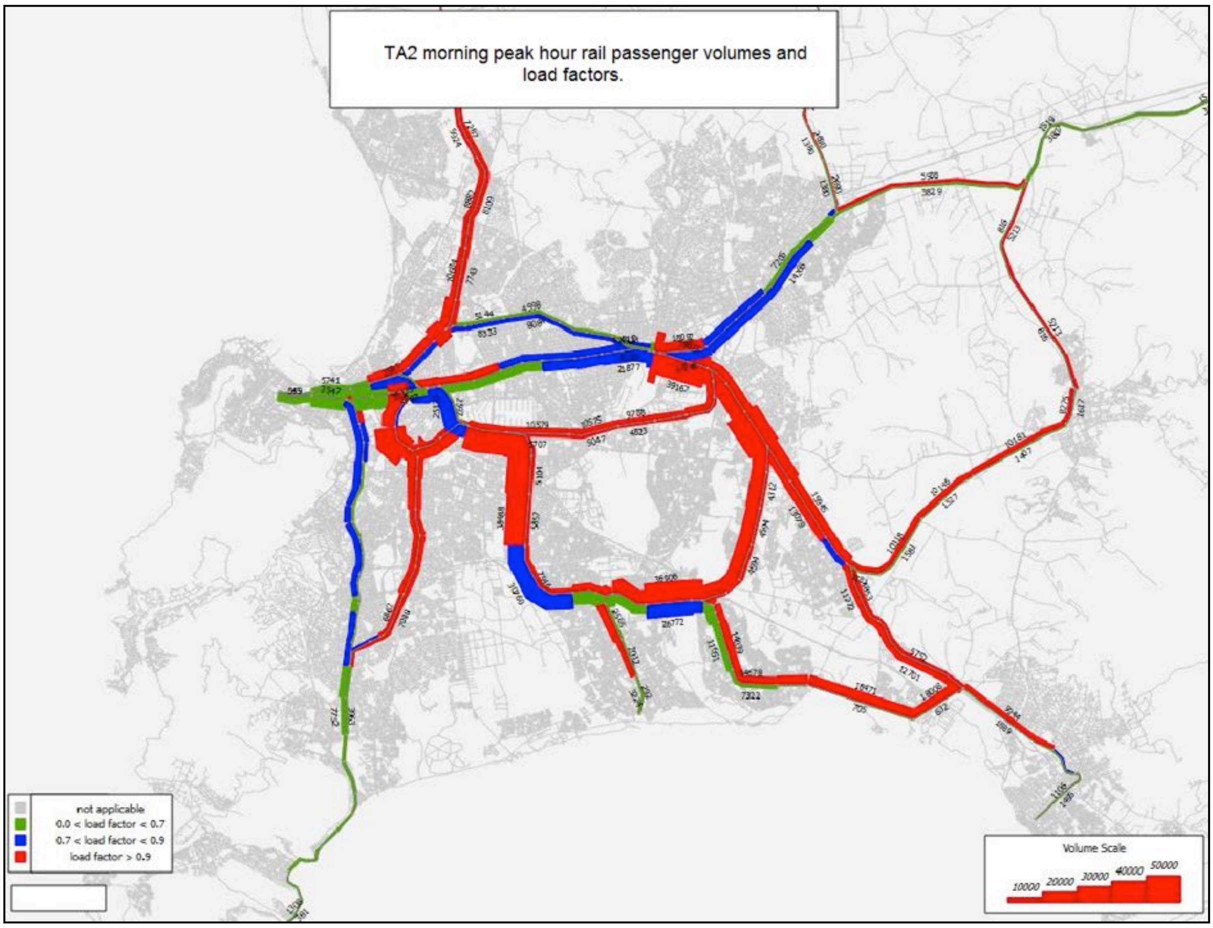


Figure 7-6: 2032 TA2 morning peak hour rail passenger volumes and load factors

It can be seen that a significant volume of passengers (about 26 000 towards Bellville) is attracted to the Blue Downs rail line, many of whom previously travelled by rail from the Metro South East and transferred at Bonteheuvel station. There is also a relatively high volume (18 000 in one direction) attracted to the Chris Hani line extension as a result of the extensive development expected between Macassar and Strand. The Atlantis line attracts about 8 000 passengers in each direction between Century City and Kynoch stations, but less than 1000 passengers northwards from Du Noon to Atlantis. The Fisantekraal line has less than 3 000 passengers in the peak direction towards Kraaifontein. The lines to the CBD attract less volumes as development focus shifts eastwards.

The 2032 peak hour passengers on the BRT trunk and feeder routes is shown in Figure 7-7.

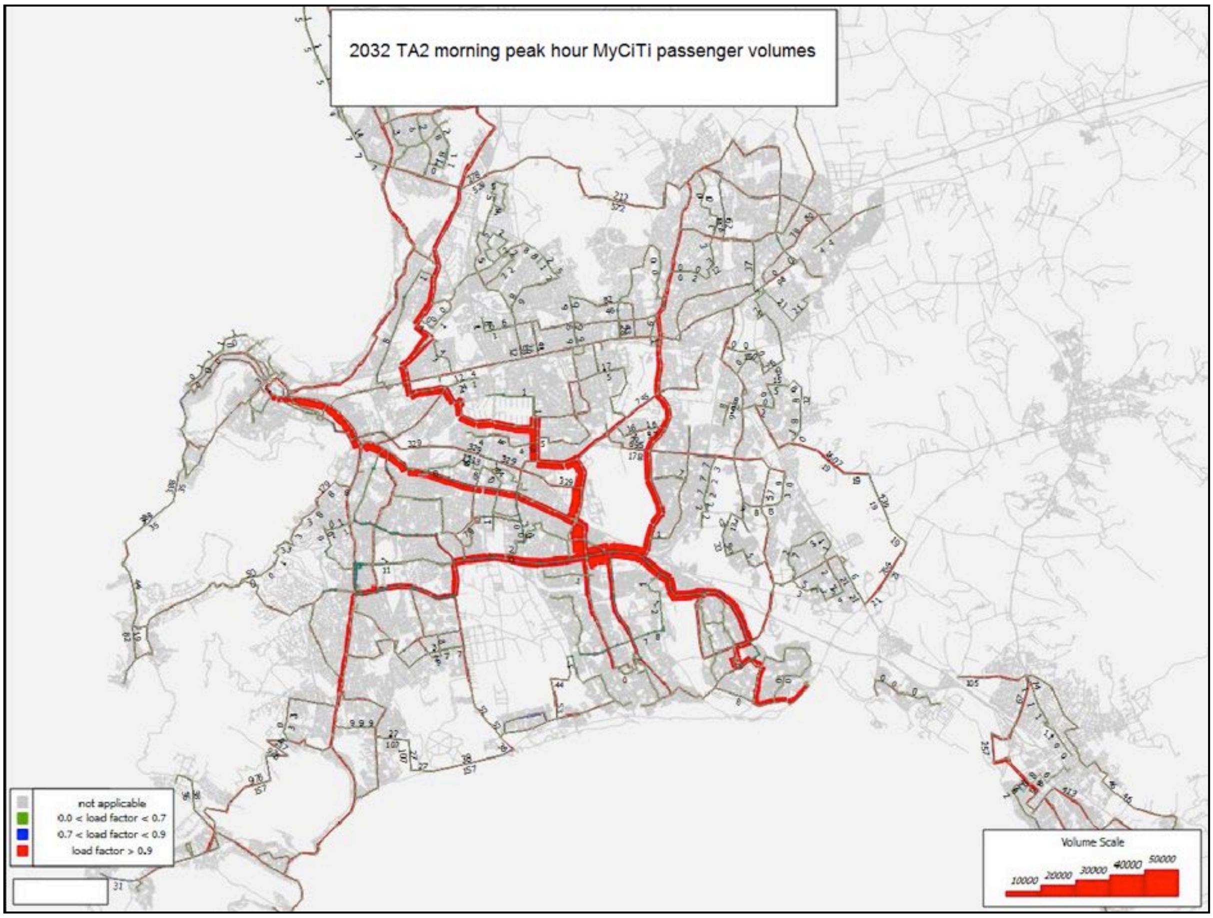


Figure 7-7: 2032 TA2 morning peak hour BRT trunk and feeder passenger volumes

The sections of BRT routes which will be carrying 8 000 to10 000 passengers per hour in the peak direction in 2032, which is the theoretical limit for BRT unless multiple platforms at stations are provide, are the following:

- T11/T12 Khayelitsha – Ottery
- T13 Symphony Way – Bellville
- T17 Crossroads – Montague Gardens
- D02 Klipfontein Road – CBD

These routes are designed to interface at a linear median closed station in Jeff Masemola Road between New Eisleben Road and Stock Road, to enable passengers to transfer between any of the destinations served by these routes. This will be the biggest BRT station in the system and will require 5 platforms to allow independent docking and departure of buses to the various destinations.

7.2.3 Network Alternative TA3

This network includes more BRT trunk routes than TA2, but fewer new rail lines. The Blue Downs rail link is included, but not the Atlantis and Fisantekraal lines, which had less than 10 000 passengers per direction in TA2, The Chris Hani line extension, although showing more than 10 000 passengers in TA2 was replaced with a BRT route in TA3 so that the results of these two alternatives could be compared in this corridor.

The private vehicle volumes on the road in the peak hour are depicted graphically in Figure 7-8. Comparison of this output with that for TA2 shows that most of the roads carry similar volumes, except that the private vehicle volumes on the roads in Somerset West and Strand are reduced in TA3. This suggests that the BRT route is better in serving the commuters in this corrirdor than the Chris Hani line extension to Firgrove station, which cannot provide the same coverage as BRT stations to the new development area between Macassar and Strand, without transfers to feeder services..

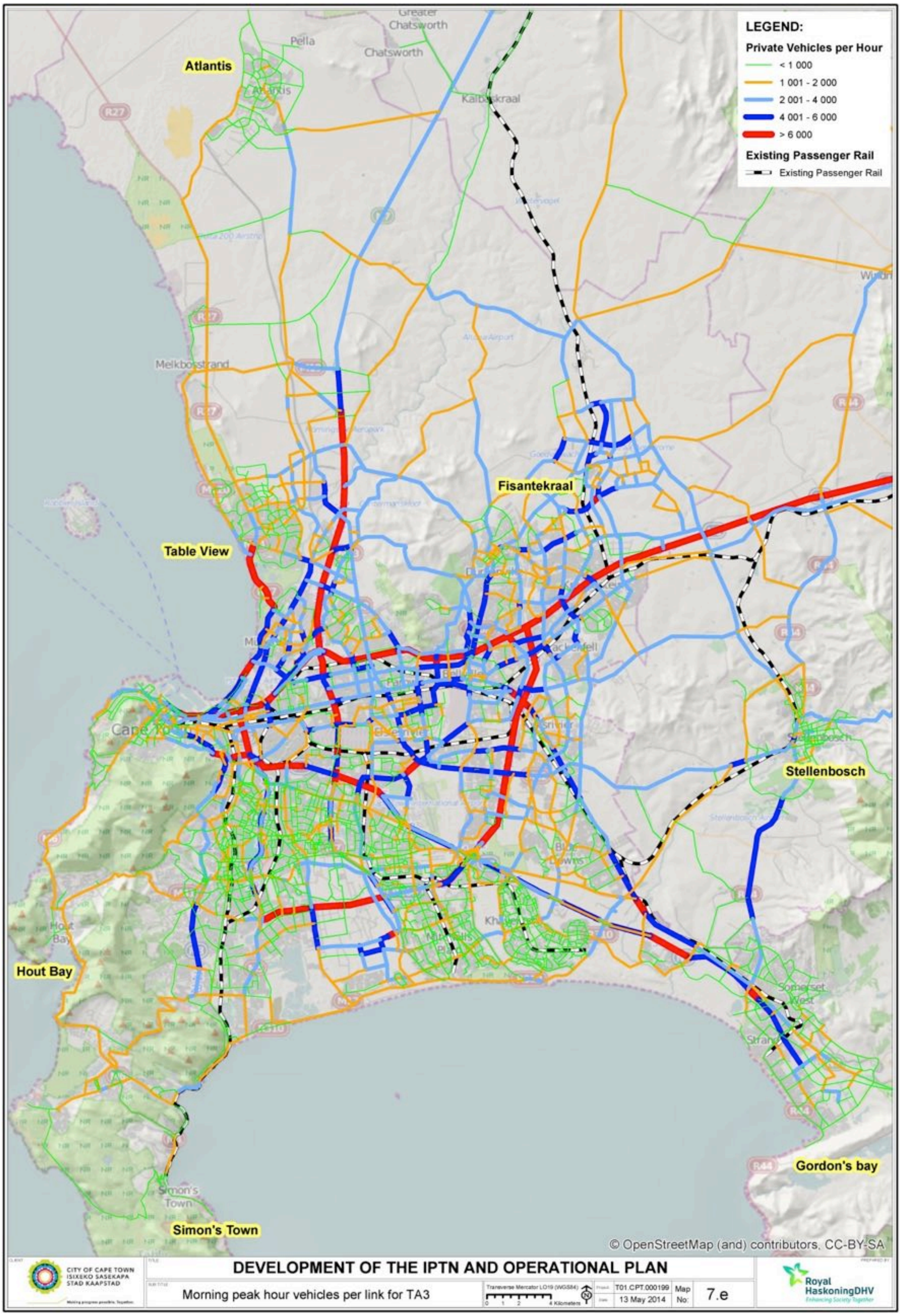


Figure 7-8: TA3 Peak Hour Private Vehicles on the Road Network 2032

The morning peak hour passenger volumes and load factors on the rail network for the TA3 alternative is shown in Figure 7-9.

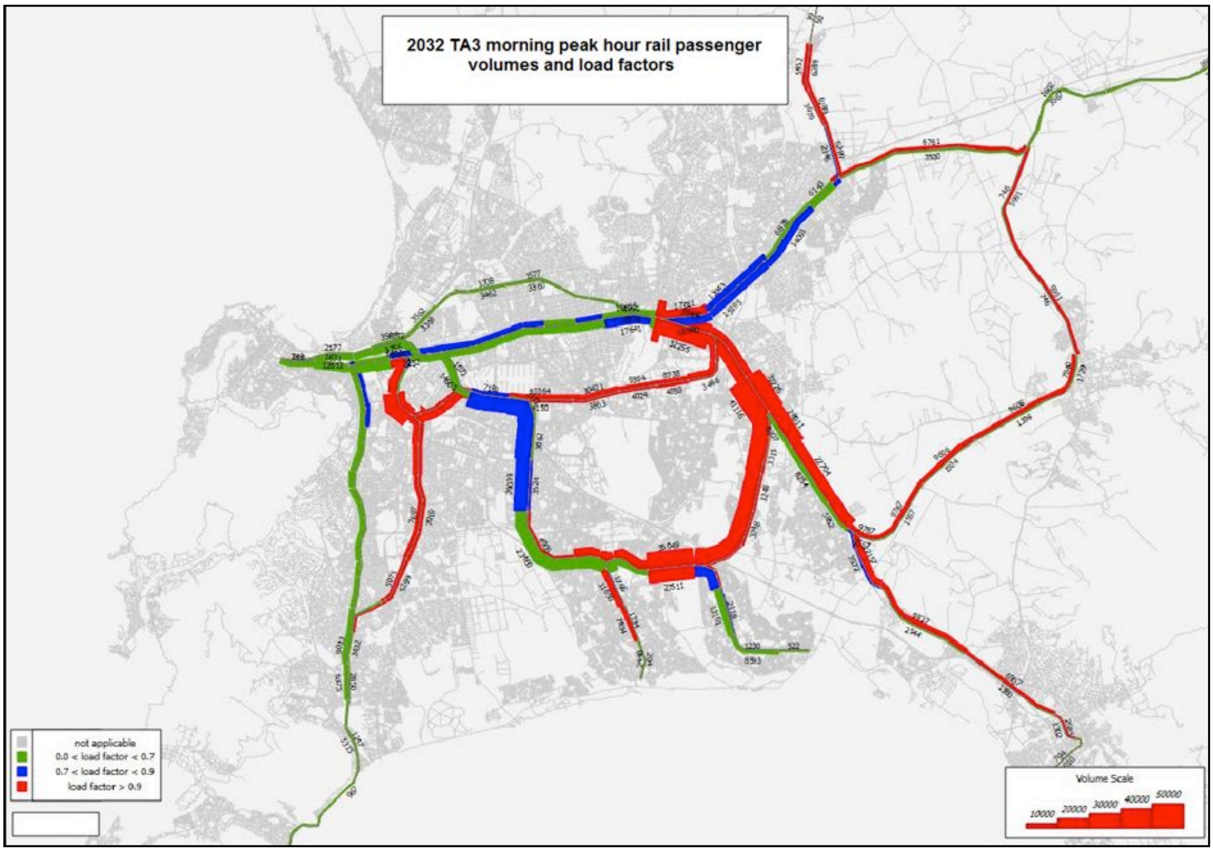


Figure 7-9: 2032 TA3 morning peak hour rail passenger volumes and load factors

The 2032 model results show that the Blue Downs line still carries a similar peak hour volume of about 25 000 passengers to that shown in TA2. The volume on the section of line between Nyanga and Mutual stations has reduced as a result of the removal of the Atlantis commuter line. Passengers who were using this line to travel from the Metro South East to Employment along Koeberg Road are now using BRT route T17 from Khayelitsha to Montague Gardens.

The peak hour passenger volumes on the BRT trunk and feeder network for TA3 is depicted in Figure 7-10.

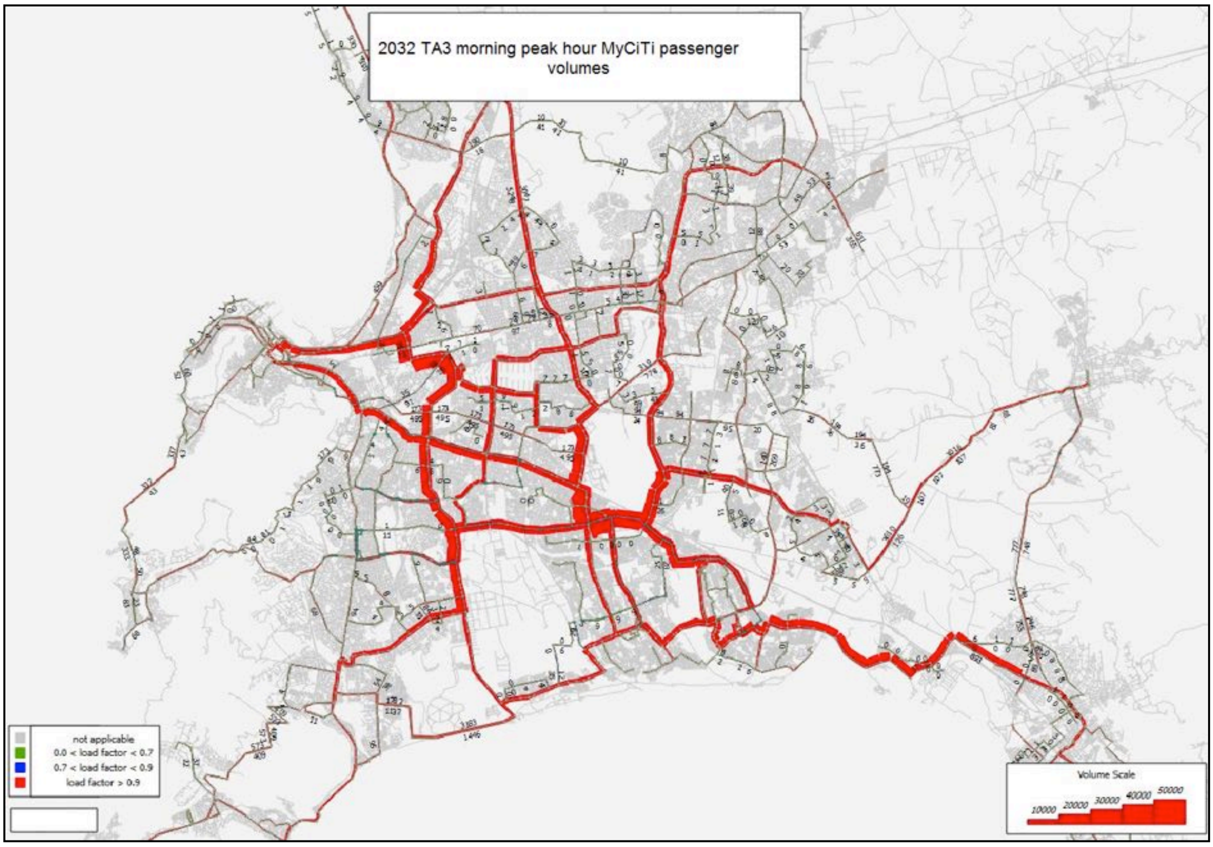


Figure 7-10: 2032 TA3 morning peak hour BRT and feeder passenger volumes

The busiest section of the BRT network continues to be the overlapping trunk sections just north of Philippi where a number of BRT routes (T11, T12, T13, T16, T17 and D02) pass through the major station in Jeff Masemola Road. The T15 route (Strandfontein-CBD) and the T10 route (Strand-Westlake) also attract high volumes especially the section of T10 from Mitchells Plain to Strand.

7.2.4 Initial findings

The operational costs of TA1, TA2 and TA3 indicate that providing a scheduled public transport network within 500m of 80% of the population, operating for 18 hours a day, far exceeds the acceptable deficit. By service type, the results are variable:

- Rail and trunk BRT revenue appears to have the potential to cover costs
- Feeder services have a high operational deficit

7.2.5 Further network alternatives: TA4

TA4 was developed out of the TA2 and TA3 trunk networks by:

- Replacing rail lines of less than 10 000 passenger/hour with road based services
- Replacing BRT routes of less than 1000 passenger/hour with distributer / feeder services
- Reducing the BRT and feeder services operational deficit to R1,9bn per annum by extensive cutback in the scheduled feeder services.

The TA4 private vehicles on the road network, shown in Figure 7-11, are similar to TA3.

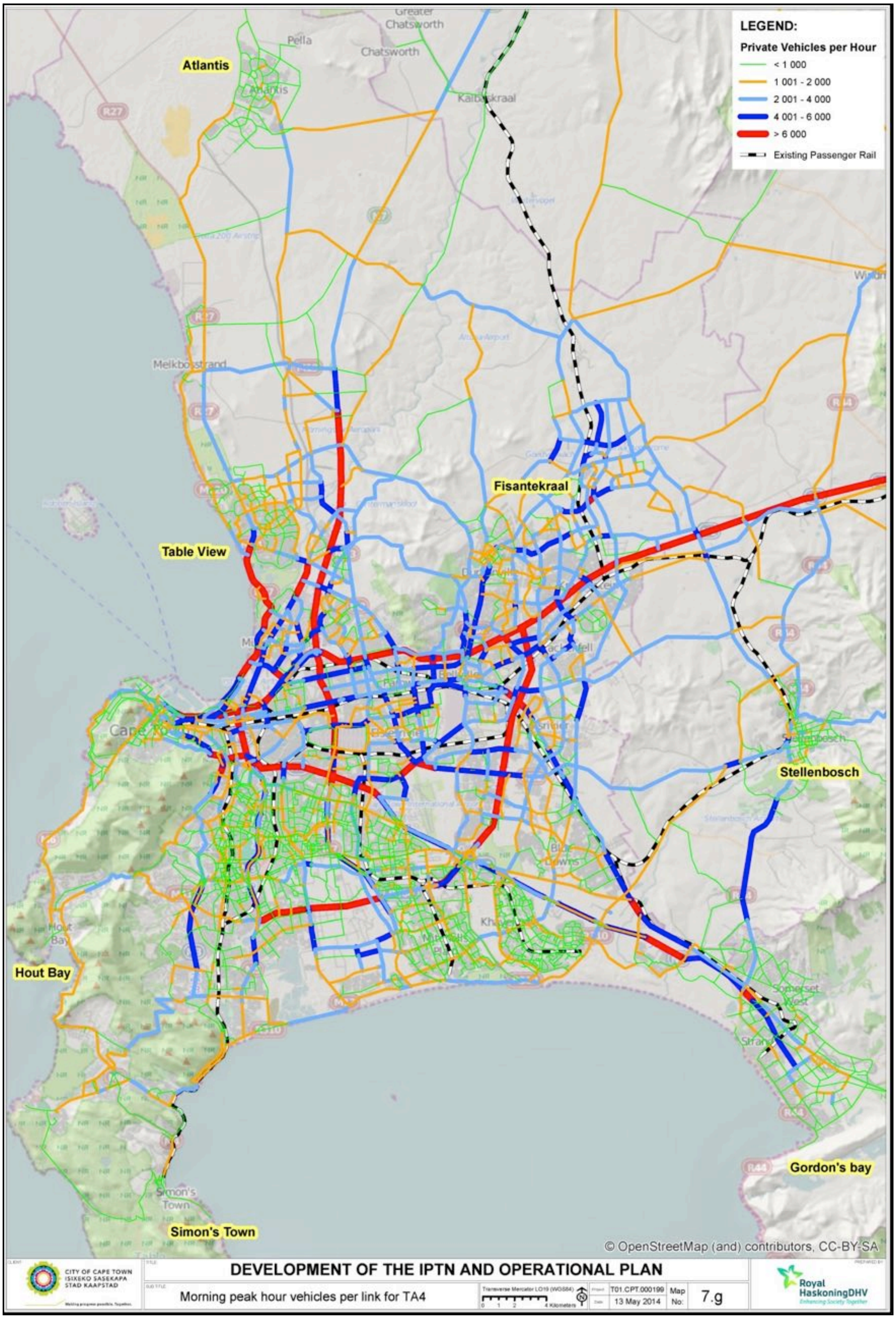


Figure 7-11: TA4 Peak Hour Private Vehicles on Road Network in 2032

Figure 7-12 indicates the rail passenger volumes as well as the load factors for TA4.

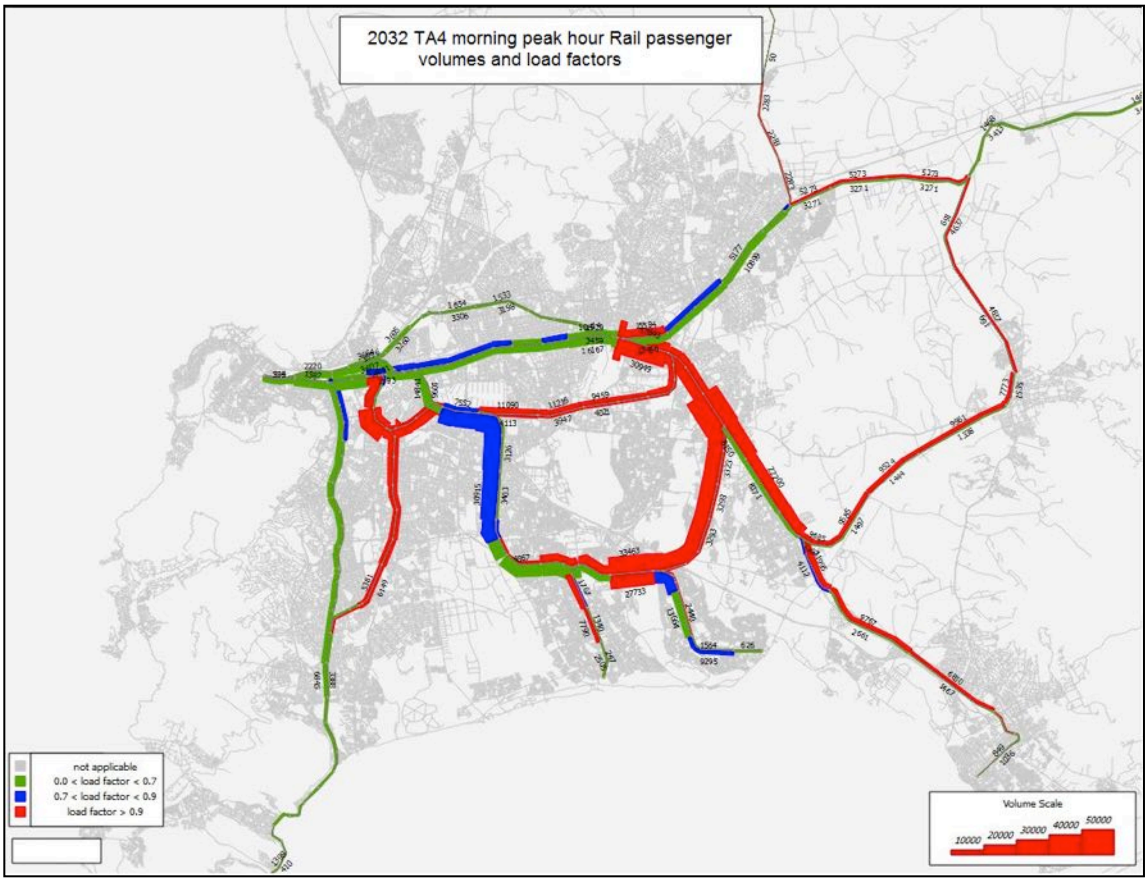


Figure 7-12: 2032 TA4 morning peak hour Rail passenger volumes and load factors

The passenger volumes on the BRT network are indicated in Figure 7-13 below.

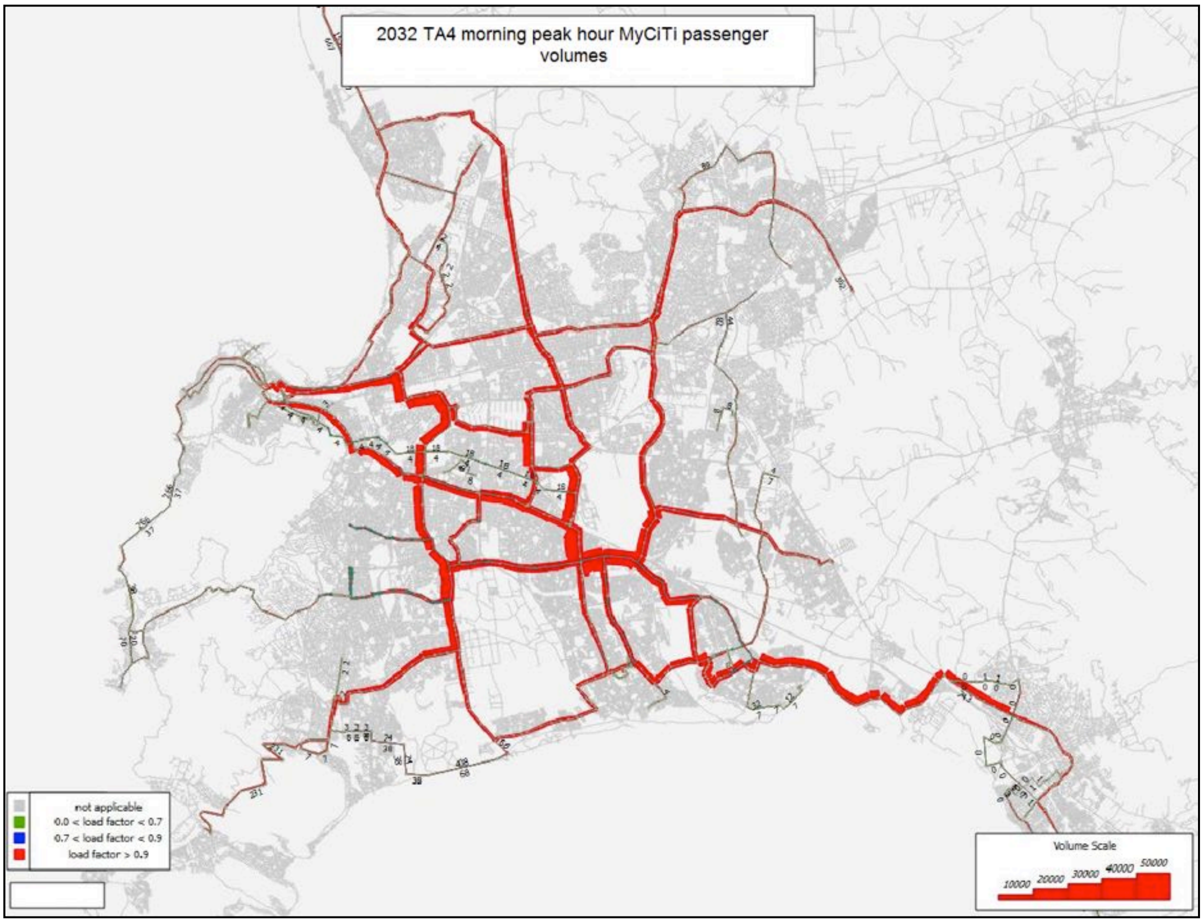


Figure 7-13: 2032 TA4 morning peak hour BRT and feeder passenger volumes

The passenger volumes on the unscheduled services provided by minibus taxis are shown in Figure 7-14 below.

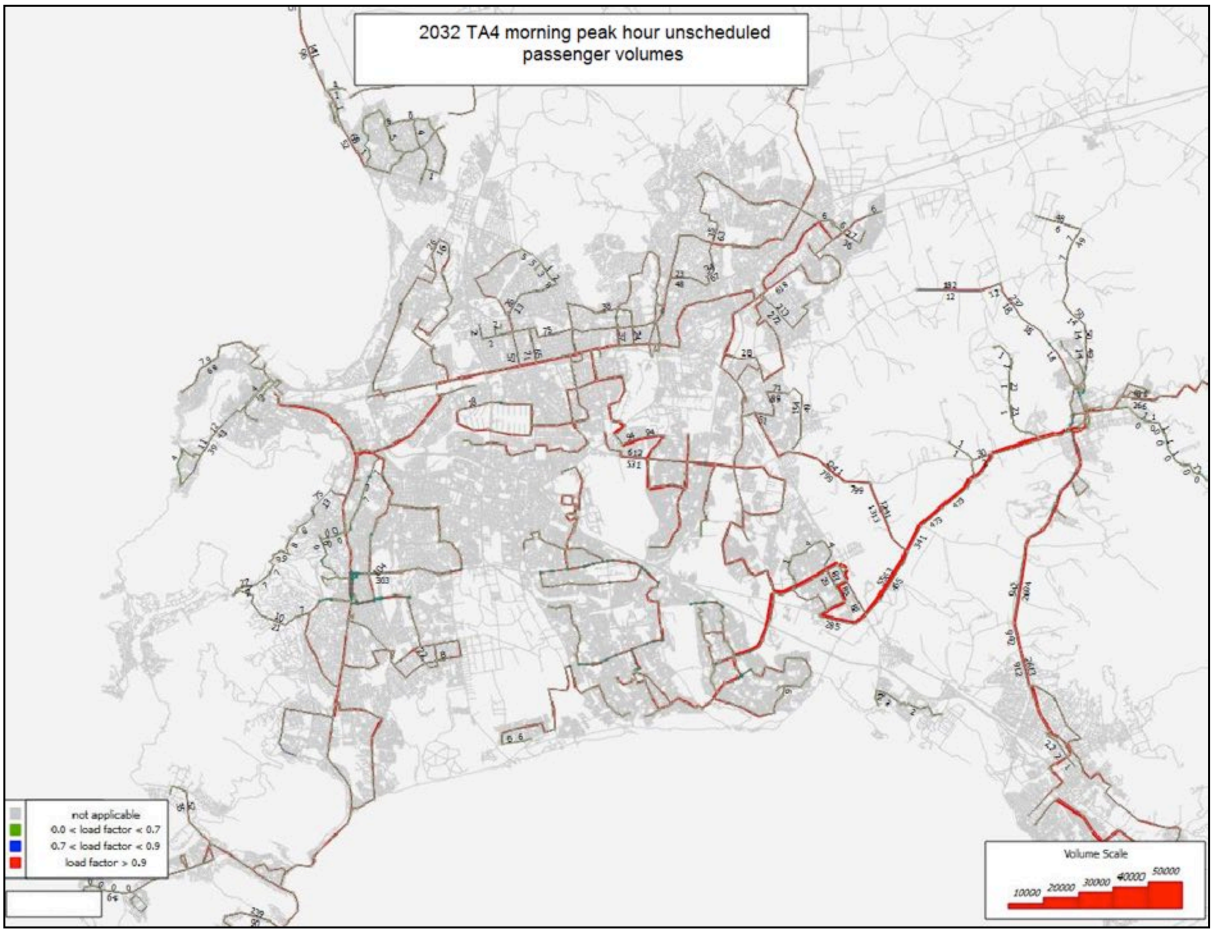


Figure 7-14: 2032 TA4 morning peak hour unscheduled passenger volumes

7.2.6 Further network alternative: TA5

Alternative TA5 uses the same trunk (rail and BRT) network as TA3. In order to reduce the deficit, two major exercises were undertaken:

- The level of service (LOS) supplied to passengers were reduced, particularly in the off peak as follows:
  - Reduce Off-peak LOS to headway of 30min for routes with a load factor of <0,65
  - No services before 5:30 and after 21:30 for routes with a load factor of <0,65

  This exercise was done on the feeder services only as most of the trunk services attracted reasonable volumes even in the off peak periods.

- The BRT trunk service peak hour capacity was capped and the passenger demand was spread over two hours by limiting supply to a 90 second headway

  This exercise was done on both the trunks and feeders although the impact on the feeders was limited.

The impact of both measures was evaluated and since the reduction of levels of services had a relatively limited effect, it was decided to remove it from any further analysis of the alternative. The results of a comparative analysis conducted outside the transport demand model are shown in Table 7-1 below.

Table 7-1: Comparative vehicle and passenger volume analysis for public transport modes

	TA3				TA5				% change			
MODE	Passengers	Scheduled Capacity	No of Veh	Week kilometres	Passengers	Scheduled Capacity	No of Veh	Week kilometres	Passengers	Scheduled Capacity	No of Veh	Week kilometres
MyCiti Trunk	3 216 825	1 533 680	3 841	2 575 910	2 972 323	1 525 315	1 889	2 551 807	-8%	-1%	-51%	-1%
MyCiti Feeder	480 910	502 835	2 178	1 111 005	376 685	393 975	1 746	978 538	-22%	-22%	-20%	-12%
Contracted Bus									0%	0%	0%	0%
Minibus Taxi	28 779	38 655	172	83 155	153 774	135 390	947	879 860	434%	250%	451%	958%
Rail	3 355 223	7 771 242	419	701 184	3 372 162	5 570 756	334	449 192	1%	-28%	-20%	-36%
All Services	7 081 737	9 846 412	6 610	4 471 254	6 874 944	7 625 436	4 916	4 859 397	-3%	-23%	-26%	9%

From the above table it can be seen that the scheduled capacity in TA5 has been significantly reduced by 23% as a result of peak capping. This only resulted in a drop of 3% in the passenger volume figure. The number of vehicles required also reduced significantly by 26% which means significantly lower costs.

8. Cost and revenue modelling

8.1 Introduction

The cost model was developed to compare the operating deficit of the various transport network alternatives that have been developed. The results of the cost model are included in the multi-criteria analysis to determine the "preferred network" for which the operational and implementation plans will then be prepared. The model uses input that is adapted from the EMME travel demand model, which was developed for the IPTN project.

8.2 Structure of Model

8.2.1 Introduction

The model has been developed using macro enabled Microsoft Excel workbooks that are linked with each other. A number of Visual Basic Macros and custom functions have been developed to automate repetitive actions and complex calculations which analyse numerous variables. The model can provide results for various operational scenarios, such as changes in operating speed, headway restrictions and cost factors, in addition to the basic analysis of the EMME demand output.

The model provides results in a format that is based on the requirements of the Department of Transport and National Treasury grant applications that are annually published in the Public Transport Infrastructure and Systems Grant Guidelines (PTIS Guidelines, 2012).

8.2.2 File Structure

All files that are necessary for the costing model are stored in various folders in the "COSTING" folder as shown in Figure 8-1.

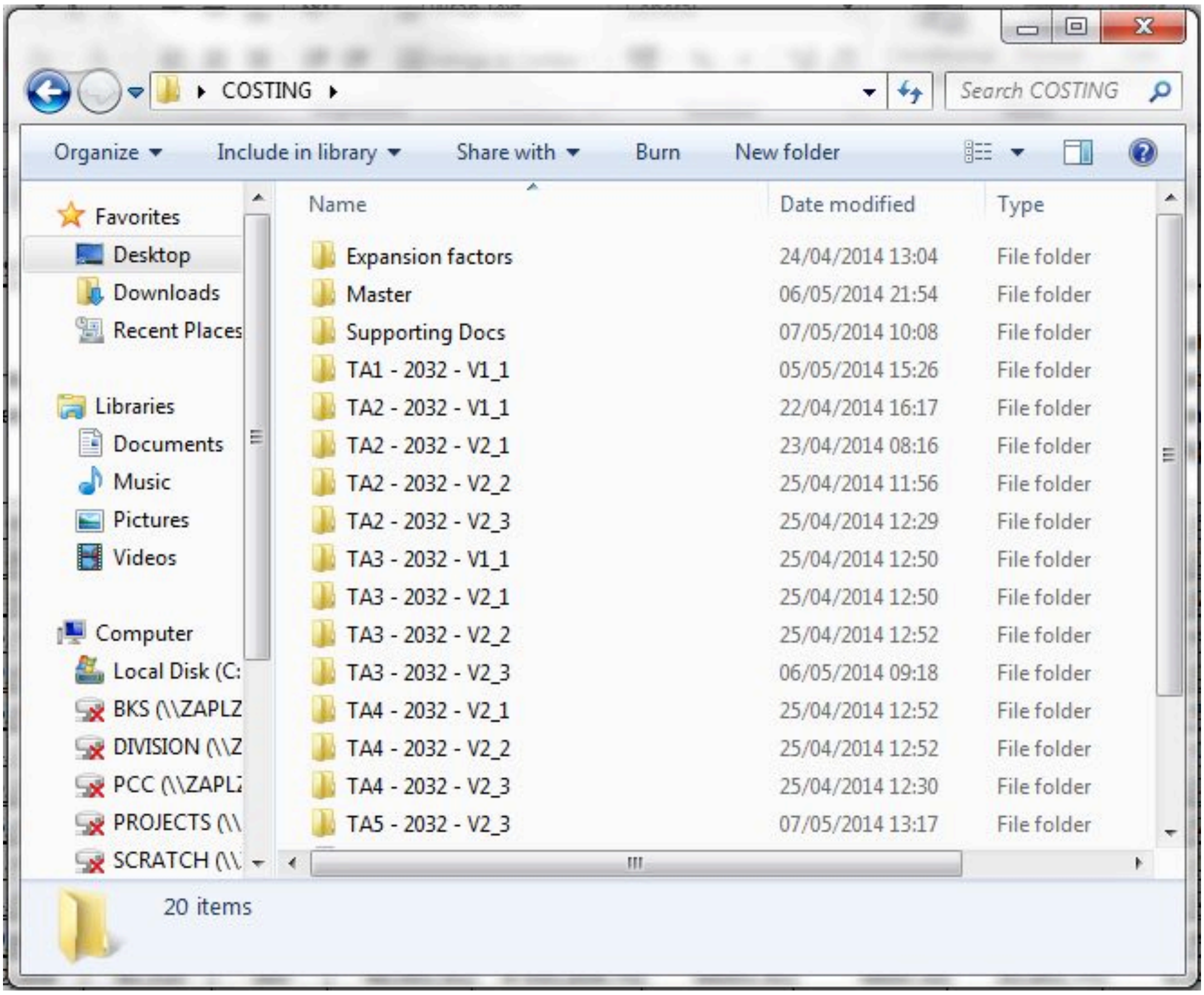


Figure 8-1: Costing Folder

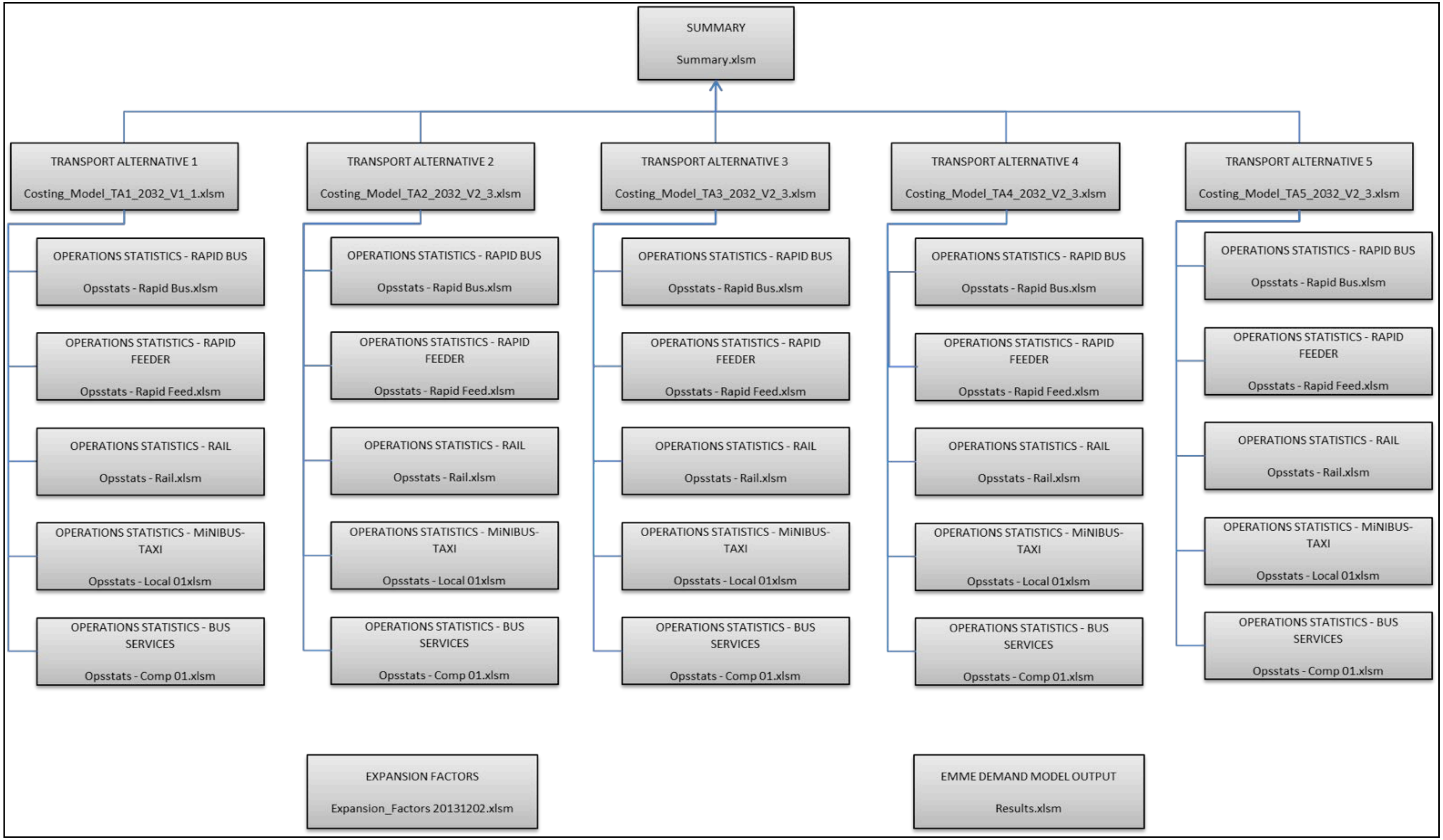


Figure 8-2: File structure of the Cost Model

Figure 8-2 provides an insight into the file structure of the model. The Summary, Expansion Factors, and EMME results are contained in the Master Folder and each scenario of the Transport Alternatives (TA) is stored in its respective sub-folder of the COSTING folder.

8.2.3 Model Theory

Most operational cost centres are either directly or indirectly related to 1) number of vehicles in use, and 2) number of kilometres travelled, and these are directly related to the demand on the route, the route profile (distance and operating speed), and the travel profile over the operating period as the supply of vehicle trips need to, at least, match the demand. It is thus essential that a cost model includes operational calculations for each route (both directions of travel) and for at least every hour of operation throughout a 24 hour day. This model calculates the vehicle supply in 30 minute time periods throughout the day to provide a more detailed input into the costing, detailed scheduling, and timetable construction that is required for further tasks of the IPTN project.

Figure 8-3 is a schematic overview of the inputs, analysis and output of the cost model.

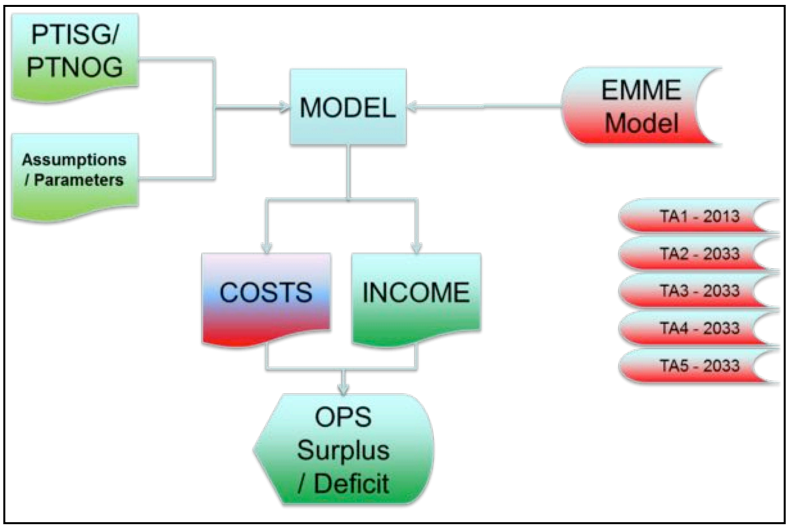


Figure 8-3: Model Theory

Inputs

The inputs into the model are:

- Information from the Department of Transport's Guidelines (PTIS Guidelines, 2012) and the Division of Revenue Act (DORA 2104, 2014) such as:
  - Grant allocations for the current MTEF periods,
  - Operational requirements for IPTN's, and
  - Format of Grant applications.
- Assumptions, Parameters and Rates:

- Assumptions such as: Interest rate, depreciation, passenger growth, economies of scale, operating profit margin, optimisation factors, negotiation premium discount.
- Parameters such as: Expansion factors, general operating speeds[9], contingencies, layover, depot distance factors, empty distance factors, vehicle capacities, spare vehicle capacity, load factors (used in fare and headway calculations, minimum and maximum headways, and headway restriction methods.
- Rates such as: Cost of fuel and energy, vehicle and equipment capital costs, vehicle cost factors, staff related cost factors, operating facility[10] cost factors, VOC contract rates, Infrastructure (capital, maintenance and operating)[11], rail operations[12] costs, and applicable fare tables (MyCiTi, Rail, GABS, and Taxi).

- EMME demand model output. Key fields of data that are used are:
    - Line,
    - Mode,
    - Vehicle Type,
    - Line Length,
    - Line Time,
    - No. of Boardings,
    - Passenger Km, and
    - Max Volume.

Outputs

The bottom line output from the model is a determination of the possible surplus or deficit, or in other words the Subsidy that may be required, which the City may be facing after all costs, income, grants and allocations from the city's rates income has all been taken into account. In the context of this application the model only calculates the costs and income that can be attributed to the operations of the entire IPTN after full implementation and does not consider infrastructure development, planning costs, transitional costs or infrastructure maintenance costs. The model provides output in 2014 Rand values and the focus for the mulit-criteria analysis is on the first year of the model. The model makes straight-line

[9] The model has the capability of calculating route running times from general operating speed parameters. However for this application this has been disabled. Rather running times as derived from the EMME demand model have been used.

[10] In this context these are offices, depots, staging areas and facilities provided for the VOC's to function effectively.

[11] The model has the capability of calculating infrastructure related costs, in this context this is not used.

[12] As PRASA did not provide any current information, the cost factors for rail were inflated by the assumed inflation rate from the 2009 figures obtained from various sources.

projections, based on current assumed inflation rates of costs and income over a twenty year span.

The model, albeit over a number of workbooks, does provide functionality for data drilling down to route level.

Operations Calculations

All calculations for operational statistics have been based on international scheduling practise as can be found in the Transportation Engineering Online Lab Manual (Bus Service Planning, 2003).

In order to calculate the cost of a public transport operation two basic factors are used as the "causes" of costs: 1) number of vehicles required to operate the service and 2) the distance travelled by those vehicles whilst providing the service.

Number of Vehicles and Capacity

The number of vehicles required is determined by a function of Cycle Time divided by the Headway supplied. The supplied headway is determined by the demand per time period on the route (supplied and derived from the EMME model) divided by the capacity of the vehicles to be used on the route where these are defined as:

Cycle Time – the total time required to complete a full cycle. The cycle included the running time and layover/recovery time.

Headway – the time that should elapse between consecutive vehicles arriving, or departing, at stations or terminal points.

The formulae used in the model are as follows:

$$Running\ time = Average\ operating\ speed\ \div line\ distance$$

$$Cycle\ Time\ = Running\ time\ (inward) + Layover + Running\ time\ (outward) + Layover$$

$$Number\ of\ vehicles\ required = Cycle\ time\ \div Headway$$ Table 8-1 indicates

Minimum practical headway = assumed to be 2 minutes (30 trips per hour)

Practical vehicle capacity = vehicle capacity X 30 trips per hour

Which results in the following:

- 6 metre vehicle – 15 passengers = 450 assume 500 maximum volume
- 9 metre vehicle – 45 passengers = 1 350 maximum volume
- 12 metre vehicle – 75 passengers = 2 250 maximum volume
- 18 metre vehicle = above 2 250 maximum volume.

Table 8-1: Capacities per vehicle

VEHICLE	Code	Legal Capacity (as per

		definition in VOC)
Artic Bus (18m) Low Entry with Right Hand doors (LERH) (EMME Code 26)	18LERH	110
Regular Bus (12m) Low Entry with Right Hand doors (LERH) (EMME code 10)	12LERH	75
Midibus (9m) Low Entry with Right Hand doors (LERH) (EMME Code 20)	9LERH	45
Minibus (6m) (EMME Code 12)	6m	15
Artic Bus (18m) Low Entry with Left doors Only (LELO) (EMME Code 26)	18LELO	110
Regular Bus (12m) Low Entry with Left doors Only (LELO) (EMME Code 10)	12LELO	75
Midibus (9m) Low Entry with Left doors Only (LELO) (EMME Code 20)	9LELO	45
Artic Bus (18m) High Floor with Right Hand doors (HFRH) (EMME Code 26)	18HFRH	120
Regular Bus (12m) High Floor with Right Hand doors (HFRH) (EMME Code 28)	12HFRHA	60
Regular Bus (12m) High Floor with Right Hand doors (HFRH) (EMME Code 10)	12HFRH	80
Commuter bus (GABS) (EMME Code 10)	12HFLH	80
Rail (8 carriage set) (EMME Code 1-5)	5M2A - 8	1995
Rail (11 carriage set) (EMME Code 1-5)	5M2A - 11	1380
Rail (12 carriage set) (EMME Code 1-5)	5M2A - 12	1700
Rail (14 carriage set) (EMME Code 1-5)	5M2A - 14	1954
Rail (12 carriage set) (EMME Code 1-5)	8M - 12	3048
Rail (8 carriage set) (EMME Code 1-5)	10M3 - 8	1650
Rail (12 carriage set) (EMME Code 1-5)	10M5 - 12	3591
Rail (14 carriage set) (EMME Code 1-5)	10M5 - 14	4194
Rail (8 carriage set) (EMME Code 1-5)	NEW - 8	1528
Rail (12 carriage set) (EMME Code 1-5)	NEW - 12	2292
Rail (14 carriage set) (EMME Code 1-5)	NEW - 14	2674
Minibus Taxi (Sesfikile) (EMME code 12)	Quant	15

From the above and the data received from the EMME demand model (Max Vol.) the headway that would be required in the peak hour (PH) to satisfy the demand is determined through the following formula:

$$Required\ frequency\ per\ hour = PH\ Demand\ or\ Max\ Vol\ \div Vehicle\ Capacity$$

$$Required\ headway = 60\ minutes\ \div frequency$$

Expansion Factors

The EMME demand model provides modelled data for the peak hour. The scope requires that the cost model and Operations plan provide an analysis that can represent annual costs. This in turn requires that the operational calculations must be “expanded” to a full day and then operating week, month and year. It is thus necessary to use expansion factors to provide the model with a method of estimating the demand for each operating period of the day.

The only methods of determining the travel profile over a route is by conducting screen line counts at strategic points along a route or boarding and alighting surveys on vehicles travelling along the route. The results of the 2008 screen-line counts were made available and additional screen-line counts were conducted along the Lansdowne – Wetton corridor. In addition, information was garnered from the MyCiTi fare management system and analysed to provide a set of expansion factors that could be used in the cost model.

The model has the capability of using an individual set of expansion factors per route, however as the limited availability of screen-line counts throughout the City made the use of this facility thus impractical, the average of available datasets was applied.

Figure 8-4 and Figure 8-5 illustrates the expansion factors that have been used in the current cost model.

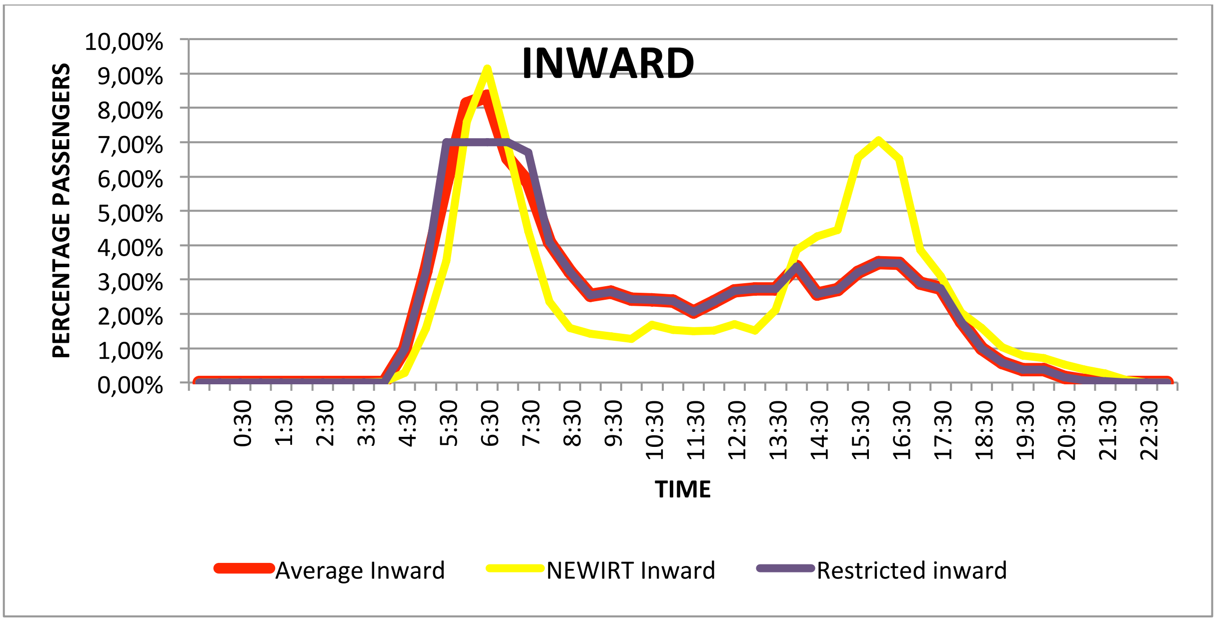


Figure 8-4: Inward expansion factors

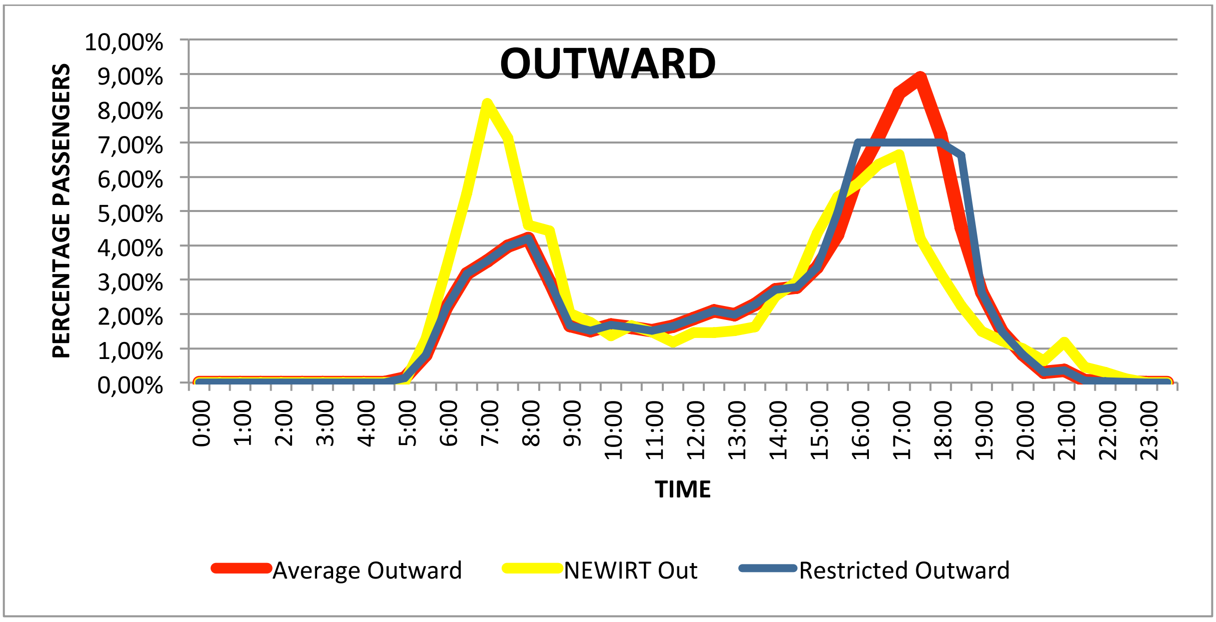


Figure 8-5: Outward expansion factors

Income Calculation

It is a requirement that the cost model reflect the estimated income that could be expected from the various mode operations. However, the complexity of the various fare policies, mode by mode, presented a challenge to accurately estimate the income.

Initially, the cost model utilised the same fare factors that were applied in the EMME demand model, but after extensive discussion this was changed to reflect a scenario as close as possible to what is actually applied in practise in the field. Changes were subsequently made for all modes to make use of fare lookup tables as described below. This required a complex formula, which could take into account the numerous parameters that are applied in order to calculate the estimated income, and in order to accomplish this, a custom VBA function was developed in the workbooks. These functions, "=FareCalc" (road based modes) and "=RailFareCalc" (rail mode), can be found in Module 1 of the Costing Model workbook.

The fare levels used in the cost model were maintained at 2013 levels, as used in the EMME model.

Rail

Currently the fare policy of rail is that of a distance based fare with six (6) levels as illustrated in Table 8-2.

Table 8-2: Rail fare structure

0.0 - 7.0km	7.1 - 16.0km	16.1 - 27.0km	27.1 - 37.0km	37.1 - 132km	132.1 - 196.0km
R 6.00	R 6.50	R 7.50	R 8.60	R 11.00	R 16.00

The "=RailFareCalc" function, in essence, is:

$$Income = Boardings \times Fare$$

$$Fare = \; lookup \; (average \; km \; per \; passenger^{13})$$

BRT and Feeder

The MyCiTi fare policy is complex in its structure and makes provision for 1) peak and off-peak travel, 2) standard fares and "Mover" fares, 3) base or boarding fares, 4) distance based rates, and 5) premium (airport) rates.

Further, for purposes of the cost model the number of transferring passengers (reduction of boardings) and the expected ratio of passengers using standard fares versus "Mover" fares needed to be included.

The lookup table used for these modes is illustrated in Table 8-3.

Table 8-3: MyCiTi fare structure

	MyCiTi Rates										
	Base Fare	5.0 - 9.9 km	10.0 - 19.9 km	20.0 - 29.9 km	29.9 - 39.9 km	40.0 - 49.9 km	50.0 - 59.9 km	60 km and up	Airport Premium	% Passengers	Transfer Factor
Peak	R 5.46	R 1.04	R 2.08	R 3.46	R 4.84	R 6.23	R 7.61	R 9.00	R 56.20	20%	10%
Off Peak	R 4.84	R 1.04	R 2.08	R 3.46	R 4.84	R 6.23	R 7.61	R 9.00	R 56.20	20%	20%
Mover Off Peak	R 4.54	R 1.04	R 2.08	R 3.46	R 4.84	R 6.23	R 7.61	R 9.00	R 38.70	80%	20%
Mover Peak	R 5.16	R 1.04	R 2.08	R 3.46	R 4.84	R 6.23	R 7.61	R 9.00	R 38.70	80%	10%

The "=FareCalc" function[14] uses a number of arguments and through a number of checks determines which rate to calculate the income from. Reductions are made to account for passengers transferring between services and for the ratio of standard vs mover fares.

Taxi income

For simplicity purposes the same function, as used for the IRT services, was used for the income calculation, however a different lookup table is referred to. Table 8-4 derived from the EMME model illustrates the structure used.

[13] $Average \; km \; per \; passenger \; = \; PH \; Passenger \; Km \; \div No \; PH \; Boardings$

[14] The detailed function is too complex to reproduce in this report. The VBA custom function can be viewed in Module 1 of the Costing Model workbook.

Table 8-4: Minibus-taxi fare structure

	Taxi Fares							
	Base Fare	5.0 - 9.9 km	10.0 - 19.9 km	20.0 - 29.9 km	29.9 - 39.9 km	40.0 - 49.9 km	50.0 - 59.9 km	60 km and up
	R 0.17							
Peak	R 6.06	R 1.26	R 2.53	R 4.22	R 5.90	R 7.59	R 9.27	R 10.96
Off Peak	R 6.06	R 1.26	R 2.53	R 4.22	R 5.90	R 7.59	R 9.27	R 10.96
Mover Off Peak	R 6.06	R 1.26	R 2.53	R 4.22	R 5.90	R 7.59	R 9.27	R 10.96
Mover Peak	R 6.06	R 1.26	R 2.53	R 4.22	R 5.90	R 7.59	R 9.27	R 10.96

8.2.4 Summary line item explanation

Operating Costs

Vehicle Operations

This category of costs includes all amounts that are directly attributed to vehicle operations that will be paid to the Vehicle Operating Companies (VOC's) and include:

- Variable costs
  - Fuel, oil, tyres and maintenance costs related to the distance travelled, and
  - Driver employment costs, Ratio per peak bus.
- Overhead costs
  - Licences, permits, insurance, facility (depot), management, supervision, and other operational costs. Ratio per peak bus.
- VOC profit.

Station Services

This includes all costs related to operations and management of stations as provided through the station services contract. The cost factors used in the model have been derived from the IRT affordability study (Affordability Report, 2014) that has recently been conducted by the City.

Fare System Management

This includes all costs related to the operations, maintenance and management of the fare system as provided through the FMS contract. The cost factors used in the model have been derived from the affordability study. (Affordability Report, 2014).

ITS and Control Centre Management

This includes all costs related to the operations, maintenance and management of the intelligent transportation systems and control centre as provided through the ITS contract. The cost factors used in the model have been derived from the affordability study. (Affordability Report, 2014).

Oversight Entity

The model uses the costs related to TCT's IRT Operations department. The cost factors used in the model have been derived from the affordability study. (Affordability Report, 2014).

System Marketing

For the purposes of the model, as in the affordability study, the income that is projected to be received from advertising on the IRT vehicles and stations will be used to market the IRT system. (Affordability Report, 2014).

Other operating costs

This is the amounts that the IRT contributes to other City Departments for services that they provide in terms of internal service level agreements. The figures used have been derived from the information available in the affordability study. (Affordability Report, 2014).

Equipment Costs

Rail, BRT, Feeder and Minibus-taxi vehicles.

This is the capital costs related to the purchase and financing of the vehicles required to operate the services. It still has to be determined if this category of costs will be carried directly by the City or if the VOC's will be responsible for vehicle procurement. In this model it assumed that the other vehicle mounted equipment, such as fare collection and ITS equipment will be included in the capital cost of the vehicles. Station equipment will be included in the capital cost of that infrastructure.

Infrastructure, Transitional and Infrastructure Maintenance Costs

The calculation of these costs are not included in this model which only calculates the operating deficit.

Income

Various income sources are described below:

Fare Revenue Rail and Road

The calculated income estimated to be received from passenger fares on the various modes.

Public Transport Infrastructure and Systems Grant (PTISG)

The grant funding that is allocated to the City of Cape Town from National Treasury for public transport infrastructure and systems as legislated in the Division of Revenue Act (Act 10 of 2014) (DORA 2104, 2014). The DORA allocates grant funding for the medium term expenditure forecast (MTEF) period of three years.

Public Transport Network Operations Grant (PTNOG)

The grant funding that is allocated to the City of Cape Town, for funding of vehicle operations and management of the IRT system, as legislated by the DORA.

Public Transport Operations Grant (PTOG)

The grant funding that is allocated to the Provincial Government of the Western Cape to fund the operations of GABS and Sibanye through the mechanism of the subsidised services contracts. It is intended that this funding will be transferred to the PTNOG as the IRT system is phased in. This funding is also legislated through the DORA.

Metrorail Operating Subsidies

Prasa receives a grant from Department of Transport to subsidise the passenger rail operations in the Western Cape including Cape Town which is estimated currently to be between R1.2bn and R1.5bn per year.

Contribution from City rates

The IRT affordability study indicated that an amount of approximately R325m could be made available from the City rates income for purposes of the IRT operations. This is based on 4% of the city's rates being allocated to subsidise public transport.

Other Income

This indicates what is expected to be received from the sale of advertising rights in IRT vehicles and facilities. This income will be used to cover the costs of system marketing.

Surplus or Deficit

The formula in the total row is simply:

$$Surplus\ or\ (Deficit) = Total\ Income\ - Total\ Costs$$

It must be noted that this is only for the operation of public transport modes in the system. The costs of the infrastructure, transitional arrangements, and infrastructure maintenance have not been calculated and this figure and is thus not in any way representative of the total IPTN system surplus or deficit.

Operations Surplus or Deficit

One of the requirements, as detailed in the DORA Guidelines, is that IPTN services should at very least cover their direct vehicle operations costs by income received from fares. This row provides an indication if this requirement is satisfied or not. It should be noted that this row includes all modes but excludes any vehicle and equipment capital costs. The formula used is:

$$Operations\ surplus\ or\ deficit = (Fare\ revenue\ excl\ rail + Fare\ revenue\ rail) - (Vehicle\ operations\ excl\ rail + Vehicle\ operations\ rail)$$

All Operations Surplus or Deficit

This row indicates the surplus or deficit for all system operating costs, inclusive of vehicle operating costs, less all income, fares and operating related subsidies or grants but still excluding equipment costs.

Subsidy required

With the assumption that TCT only has the mandate and responsibility to operate or cause to be operated, road based contracted scheduled public transport, this row is intended to indicate what levels of subsidisation would be required to cover the deficit of all road based operations.

8.3 Development of Scenarios

As with most models, the development of this cost model went through a number of improvements in order to 1) align it as close as possible to past work and studies that have been done in the IRT project, and 2) to determine what interventions would need to be implemented to achieve the most cost effective network and operating parameters for the IPTN. From the outset the model was developed to analyse each network alternative using the same parameters and factors which could be expected to be practically realised through implementation of that alternative.

8.3.1 Scenario 1.1

This scenario was the initial model in which the TA1 "do minimum" network alternative was analysed. A standard fare income calculation was applied to all modes. The further development of the control macros and import regimes was undertaken during this process. Checks and balances were implemented to ensure that the EMME data was properly imported into the Opstats workbooks.

Numerous route numbers, as used in the EMME model, had to be edited so that the cost model could add the matching reverse direction to the route analysis sheet.

Following discussions with City officials on 21 January 2014 the following adjustments were made on all Scenario 1.1 models:

- Adjusted the spare vehicle factor to:
    - 7% road vehicles, and
    - 5% rail vehicles.
- Adjusted the Peak Vehicle optimisation factor to:
    - 40% Road, and
    - 20% Rail.
- Added Present Value column at the end of the cost sheets,
- Updated the Vehicle Operating factors,
- Included a negotiation premium factor reduction of 5%, and
- Included a transfer factor reducing the boardings for purposes of fare income calculations.

8.3.2 Scenario 2.1

The following improvements were made to TA2 and TA3. TA4 was created, with the same parametres, after analysis of TA2 and TA3 results in workshops with City officials:

- The functionality of selecting the appropriate size of vehicle for BRT trunk and feeder services based on passengers per hour as follows:
    - 0 – 500 = 6m vehicle,
    - 501 – 1350 = 9m vehicle,
    - 1351 – 2790 = 12m vehicle, and
    - > 2491 = 18m vehicle.
- Corrected the rail vehicle types and capacities, to what is used in practice by Metrorail.
- Added kilometre optimisation factors,
    - 30% Road, and

        - 15% Rail.
  - Increased cost to company for drivers to R145 000 per year,
  - Included the number of stations envisaged into the Station and Stops Capital Sheet and linked the Station Operational Cost sheet to these figures. Included the Fare Management Costs,
  - Included other Operations costs,
  - Adjusted the negotiation premium reduction factor to 10%,
  - Included an Economies of Scale discount factor of 15% only on Operations Costs,
  - Redeveloped the Fare Income calculation to take into account: peak/off peak fares; the fare level steps; mover/standard splits; airport premium; boarding; transfer factor,
  - Redeveloped the Rail Fare calculation to include the various fare steps in the RailFares table,
  - Included the NEWIRT expansion factors as received from the City. Changed average factors to only refer to the E-W movement along the Lansdowne Wetton Corridor,
  - Amended Capital cost calculation to annualise (including Interest) the cost of capital for All Equipment,
  - Matched the cost of Marketing to the income estimated from Advertising on the system,
  - Inflated rail cost factors by the annual inflation factor (6.5%) from 2009 levels. Note cost of electricity is inflated by this rate as well,
  - Amended the vehicle passenger capacities to:
    - 18mHF = 120;
    - 18mLE = 110;
    - 12mHF = 80;
    - 12mLE = 75;
    - 9m = 45; and
    - 6m = 15.
  - Included default headways(HW) in the route calculations where calculated HW are below the default level - Off peak periods only (so as to not affect the PV calculations),
  - Corrected the direction of travel between the EMME and the cost model, matched the route direction with the highest demand to be classed as the " inward" journey so as to use the correct expansion factor,

  - Included a Surplus/Deficit Column in Service Data..

8.3.3 Scenario 2.2

This scenario was a test scenario in which all the optimisation and economies of scale factors were set to zero.

8.3.4 Scenario 2.3

In this scenario the optimisation and economies of scale factors were returned to the agreed levels and the fare levels were reset to 2012/13 levels as used in the EMME model.

After evaluation of TA2, TA3, and TA4 alternatives, TA5 was created based on TA3 with the following refinements:

- Increased the operational speed on selected Feeder routes,
- Reduced off-peak services that had a load factor of less than 0.75 to 1 trip per hour,
- Introduced headway restrictions, peak capping, on BRT routes to a minimum headway of 60 seconds,
- Introduced revised expansion factors to "flatten" the peaks, to simulate passenger movement to the shoulders of the peak to accommodate some of the passengers lost due to the headway restrictions.

Version 2: 05 May 2014

- Removed the off-peak service reduction and reset to maintain standard off-peak headways,
- Added the functionality to select a headway restriction for road and rail based modes:
  - MaxHW – apply a maximum headway of 1 trip per hour for each time period if demand is less than specified load factor (Min_Load_Fact = 0.75),
  - StdHW – apply Standard ITP headways to period where demand is less than specified load factor (Min_Load_Fact = 0.75), and
  - No Restriction – do not apply any headway restriction i.e. maintain calculated headways.
- Set only TA5 to:
  - Rail = MaxHW,
  - Road = StdHW.
- Converted seven (7) IRT Feeder routes to minibus-taxi routes:
  - F01,
  - F02,
  - F03,
  - F80,
  - F86,
  - M17, and
  - T9.

8.4 Sensitivities

Through the development of the above scenarios it was confirmed that the cost model was sensitive to a number of factors. The most significant of which are identified below:

8.4.1 Cost Factors

The model makes use of cost factors such as the cost of fuel and electricity, consumption per kilometre, insurance rates, staff remuneration rates, spares and other consumables to mention a few. Care has been taken in determining the level of each of these rates and they have been discussed at length with City officials and agreement has been reached on most rates and factors. However, costs are always fluctuating and can have a profound effect on the outcome of the model. The rates used are set at 2013 levels.

8.4.2 *Operating Speed*

As discussed in section, the average operating speed directly affects the running time and cycle time of vehicles operating the route. An increase of operating speed results in a reduction in the number of vehicles required and thus a reduction in all vehicle related costs, as opposed to distance based costs, including capital, drivers, depot, licences, permits, management, supervision, and other operational overheads.

Table 8-5 below illustrates the effect of increased speed:

Table 8-5: Example of increased operating speed

Route Distance (km)	**Operating Speed (km/h)**	**Running time (h:mm)**	**Cycle Time (2 x running time + 2 x 10% running time)**	**Headway required (minutes)**	**Estimated Passengers (peak period – 3hrs, veh_ cap = 110)**	**No of Buses**
30	20	1:30	3:18	1	20 000	198
30	25	1:12	2:38	1	20 000	158

It will be noted that to carry the same amount of passengers but at a 5 km/hr higher operating speed 40 fewer buses are required. Therefore it would be very advantageous for all efforts to be made in order to achieve the fastest possible operating speeds on the routes. These should include, but not be limited to, dedicated lanes throughout the length of the trunk routes, effective bus priority measures implemented on all routes at intersections, and minimisation of dwell time at stops for alighting and boarding.

8.4.3 *Expansion Factors*

As discussed earlier, the use of correct expansion factors in the model is paramount in determining 1) the number of trips required to satisfy the peak period demand, 2) the travel profile throughout the operating day, 3) the total number of expected passengers, and 4) the income that could be received from these passengers. The estimation of the expansion factors influences the operating costs and income calculations of the model.

8.4.4 *Route Direction*

Route travel direction in the cost model must be matched with the travel direction as in the EMME demand model, as the application of the incorrect direction's expansion factors will cause a skewed result. Care was taken to ensure that the directions were matched on all trunk routes. For the feeder routes the direction with higher demand was matched to the "Inward" expansion factor.

8.4.5 *Vehicle Capacity*

As discussed previously, the type of vehicle used needs to be aligned with the expected volume of passengers on the route. By making use of a smaller vehicle increases the number of vehicles required and the number of trips, and therefore the total distance travelled. In the model this would result in higher costs to move the same amount of passengers.

8.4.6 Fare Policy and Fare Levels

The model is sensitive to the use of the correct fare policy for each mode, as currently each mode has a different policy for its fares. Initially it was assumed that after full IPTN implementation all modes would operate under the same policy that would be determined by TCT, but this was amended to only the contracted road based modes. Rail and minibus-taxis would remain with their own policies. This had a significant effect on the total fare income that was calculated in the model.

The levels of the fares need to be based on the same period; the model is currently making use of the 2013 fare levels for all modes.

As the EMME model also considers the different policies and levels when calculating the mode choice assignment, it was considered important to use similar theory in the cost model with the exception of the BRT trunk and feeder services where the MyCiTi fare policy was applied.

8.5 Results

It was decided that Transport Network Alternative TA1 – "Do Minimum" would be used as the base against which all other alternatives would be compared and this was the first alternative to be analysed through the cost model (TA1_V1.1).

For the purposes of the MCA the figures used are indicated in the row headed Subsidy Required. This figure is calculated in the following manner:

$$
\begin{aligned}
&SUBSIDY\ REQUIRED\ (per\ year) \\
&\quad = \big((Road\ based\ operations\ costs - minibus\ taxi\ operations\ costs) \\
&\quad + system\ opertating\ costs + (Equipment\ Costs - minibus\ taxi\ equipment)\big) \\
&\quad - (Road\ based\ fare\ income - minibus\ taxi\ fare\ income)
\end{aligned}
$$

This figure indicates the total subsidy, from all sources, that would be required to operate the road-based services within the City's mandate. It is assumed that the City will hold the mandate for all contracted road public transport which will include BRT Trunk and Feeder services and that GABS will be part of the VOC's involved in the IPTN. This result also assumes that the VOC's will be responsible for financing the equipment costs, such as Vehicle Capital and the vehicle installed Fare and ITS equipment, as per the current DoT directive.

8.5.1 Base – TA1

The tables below show the results of the analysis of TA1 which indicates that R2.615bn annual subsidy would be required to operate this alternative.

Table 8-6: Financial Results TA1

Scenario 1.1	TA1 - Do Minimum
ITEM	Year 1
	TOT
COSTS (R - ,000)	**R 41 719 942**
Planning costs	R -
Operating costs	**R 30 207 292**
Vehicle operations (Excl Rail)	R 24 398 951
Vehicle operations (Rail)	R 4 007 313
Station services	R 215 073
Fare system management	R 314 322
ITS and control centre mgmt.	R 37 568
Oversight entity	R 152 946
System marketing	R 103 462
Other	R 977 657
Equipment costs	**R 11 512 651**
Rail vehicles	R 7 151 134
Trunk vehicles (Articulated)	R 92 829
Complementary vehicles (other buses)	R 1 817 018
Feeder vehicles	R 123 923
Minibus-Taxi	R 2 327 747
Fare system equipment (Included in Capital cost of vehicl	R -
ITS equipment (Included in Capital cost of vehicles)	R -
Other (specify)	R -
Infrastructure costs	R -
Transitional costs	R -
Infrastructure maintenance	R -
INCOME (R - ,000)	**R 16 054 493**
Fare Revenue (Excl Rail)	R 8 573 768
Fare Revenue (Rail)	R 3 686 662
PTISG	R 999 466
PTNOG	R 217 548
PTOG	R 779 365
Metrorail Operating Grant	R 1 350 000
Contribution from City Rates	R 325 963
Other Income	R 121 720
Surplus/(Deficit)	R -25 665 450
Operations Surplus/(Deficit) (Farebox - Veh Ops)	R -16 145 833
All Operations (Ops Cost - Fare Box + Ops Subsidy)	R -15 152 265
SUBSIDY REQUIRED (road based Fare income - (Road operations costs + MyCiTy stations etc. + Equipment costs (Vehicles)) excluding all costs and fares attributed to taxis)	R 2 615 791
Operational Deficit before subsidies (BRT trunk and scheduled feeders only)	R -2 483 823
Operational Deficit after subsidies (BRT trunk and scheduled feeders only)	R -1 039 226

The operations statistics for this alternative are indicated in Table 8-7 below:

Table 8-7: Operations statistics TA1

1.1	TA 1					
Service	No of Services (per w_day)	Estimated Passengers (per w_day)	Scheduled Capacity (per w_day)	No of Vehicles (Optimised, Incl Spares) (per w_day)	Estimated Weekly (Mon-Sun) kilometres (Initial Calcs)	Estimated Income (w_day)
TOTAL IRT	4	71 086	89 130	193	119 687	R 343 948
TOTAL IRT FEEDER	27	51 239	108 135	353	114 086	R 247 062
TOTAL BUS SERVICES	900	1 139 979	3 370 240	4 416	3 865 837	R 9 571 370
TOTAL MINIBUS	712	3 085 099	3 608 715	32 483	18 907 108	R 16 498 203
TOTAL RAIL	46	1 710 728	5 032 631	386	366 300	R 11 463 869
TOTAL ALL SERVICES	**1 689**	**6 058 131**	**12 208 851**	**37 831**	**23 373 017**	**R 38 124 451**

Notable in this alternative is the high number of bus services/routes, 900, that are being operated by GABS and Sibanye and that their fleets will need to increase to 4, 416 buses to satisfy the 2032 demand. The minibus-taxi mode will be conveying more than half of the total estimated passengers in the year 2032 and operating 81% of the kilometres for only 46% of the total fare income.

8.5.2 Scenario 2.3

Following a number of iterations, which were undertaken to improve the accuracy of the model, Scenario 2.3 was the final scenario developed in the model and all alternatives have been analysed using this cost modelling scenario. TA5 is the exception as this alternative was a derivative of TA3 V2.3 and no EMME model run was conducted.

TA5 Enhancements from TA3 were:

1. Initially the off-peak services on all modes was reduced to a minimum of 1 trip per hour, but this was later reversed as it was deemed more important to maintain a minimum 20 minute level of service on all routes during the off-peak periods,
2. Introduced headway restrictions on peak services to a minimum of 60 seconds,
3. Introduced a revised expansion factor which is intended to spread passengers over a longer peak period due to the headway restrictions,
4. Transferred seven BRT Feeder routes to minibus taxi to reduce the required subsidy to an affordable level with regard to current grants.

Results of the Scenario 2.3 modelling are shown in Table 8-8, with the subsidy required (excluding minibus taxi operating costs) as follows:

Subsidy Required:

- TA1 R 2.615bn
- TA2 R 8.201bn
- TA3 R 6.424dn
- TA4 R 4.702bn
- TA5 R 2.752bn

It is also notable that the direct vehicle operations costs (all modes)are covered by the fare revenue for TA4 (by R 2.082bn) and TA5 (by R 4.086bn) and this surplus contributes to covering the system operating costs quite significantly for these alternatives.

Table 8-8: Financial Results Scenario 2.3

Scenario 2.3	TA1	TA2	TA3	TA4	TA5
ITEM	Year 1	Year 1	Year 1	Year 1	Year 1
	TOT	TOT	TOT	TOT	TOT
COSTS (R - ,000)	R 41 719 942	R 28 343 098	R 26 104 428	R 24 589 220	R 19 379 070
Planning costs	R -	R -	R -	R -	R -
Project Management	R -	R -	R -	R -	R -
Operations Plan	R -	R -	R -	R -	R -
Business Plan	R -	R -	R -	R -	R -
Marketing & Communications Plan	R -	R -	R -	R -	R -
Preliminary and Detailed Infrastructure Design	R -	R -	R -	R -	R -
Other (AFC and ITS)	R -	R -	R -	R -	R -
Operating costs	R 30 207 292	R 17 035 374	R 15 738 921	R 14 399 831	R 11 859 493
Vehicle operations (Excl Rail)	R 24 398 951	R 7 040 201	R 7 024 568	R 5 922 444	R 5 102 968
Vehicle operations (Rail)	R 4 007 313	R 6 548 767	R 5 477 589	R 5 310 047	R 3 942 117
Station services	R 215 073	R 1 338 346	R 1 338 346	R 1 338 346	R 1 338 346
Fare system management	R 314 322	R 434 123	R 387 827	R 351 631	R 278 452
ITS and control centre mgmt.	R 37 568	R 49 479	R 44 517	R 43 948	R 35 280
Oversight entity	R 152 946	R 152 946	R 152 946	R 152 946	R 152 946
System marketing	R 103 462	R 103 462	R 103 462	R 103 462	R 103 462
Other	R 977 657	R 1 368 050	R 1 209 665	R 1 177 007	R 905 921
Equipment costs	R 11 512 651	R 11 307 724	R 10 365 508	R 10 189 389	R 7 519 577
Rail vehicles	R 7 151 134	R 9 237 291	R 7 472 009	R 7 225 201	R 5 967 513
Trunk vehicles (Articulated)	R 92 829	R 1 295 669	R 2 420 544	R 2 335 550	R 1 132 060
Complementary vehicles (other buses)	R 1 817 018	R 275 779	R 149 457	R 254 618	R 88 313
Feeder vehicles	R 123 923	R 228 539	R 221 166	R 307 878	R 178 337
Minibus-Taxi	R 2 327 747	R 270 447	R 102 331	R 66 143	R 153 353
Fare system equipment (Included in Capital cost of vehicl	R -	R -	R -	R -	R -
ITS equipment (Included in Capital cost of vehicles)	R -	R -	R -	R -	R -
Other (specify)	R -	R -	R -	R -	R -
Infrastructure costs	R -	R -	R -	R -	R -
Transitional costs	R -	R -	R -	R -	R -
Infrastructure maintenance	R -	R -	R -	R -	R -
INCOME (R - ,000)	R 16 054 493	R 15 200 913	R 16 186 756	R 17 108 755	R 16 926 111
Fare Revenue (Excl Rail)	R 8 573 768	R 3 862 387	R 6 571 699	R 7 666 487	R 6 114 556
Fare Revenue (Rail)	R 3 686 662	R 7 544 463	R 5 820 994	R 5 648 205	R 7 017 493
PTISG	R 999 466	R 999 466	R 999 466	R 999 466	R 999 466
PTNOG	R 217 548	R 217 548	R 217 548	R 217 548	R 217 548
PTOG	R 779 365	R 779 365	R 779 365	R 779 365	R 779 365
Metrorail Operating Grant	R 1 350 000	R 1 350 000	R 1 350 000	R 1 350 000	R 1 350 000
Contribution from City Rates	R 325 963	R 325 963	R 325 963	R 325 963	R 325 963
Other Income	R 121 720	R 121 720	R 121 720	R 121 720	R 121 720
Surplus/(Deficit)	R -25 665 450	R -13 142 185	R -9 917 673	R -7 480 465	R -2 452 958
Operations Surplus/(Deficit) (Farebox - Veh Ops)	R -16 145 833	R -2 182 118	R -109 464	R 2 082 201	R 4 086 963
All Operations (Ops Cost - Fare Box + Ops Subsidy)	R -15 152 265	R -2 833 927	R -551 631	R 1 709 458	R 4 067 153
SUBSIDY REQUIRED (road based Fare income - (Road operations costs + MyCiTy stations etc. + Equipment costs (Vehicles)) excluding all costs and fares attributed to taxis)	R 2 615 791	R 8 201 239	R 6 424 906	R 4 702 338	R 2 752 979
Operational Deficit before subsidies (BRT trunk and scheduled feeders only)	R -2 483 823	R -6 455 182	R -3 649 902	R -2 101 481	R -1 447 530
Operational Deficit after subsidies (BRT trunk and scheduled feeders only)	R -1 039 226	R -5 010 585	R -2 205 305	R -656 884	R -2 933

The operations statistics for these alternatives are shown in the following tables:

Table 8-9: Operations statistics TA2

2.3	TA 2					
Service	No of Services (per w_day)	Estimated Passengers (per w_day)	Scheduled Capacity (per w_day)	No of Vehicles (Optimised, Incl Spares) (per w_day)	Estimated Weekly (Mon-Sun) kilometres (Initial Calcs)	Estimated Income (w_day)
TOTAL IRT	11	1 526 101	872 805	2 276	1 347 009	R 8 463 675
TOTAL IRT FEEDER	99	638 752	666 665	4 169	1 699 248	R 2 998 106
TOTAL BUS SERVICES	-	-	-	-	-	R -
TOTAL MINIBUS	13	75 523	82 035	585	304 044	R 548 514
TOTAL RAIL	49	4 074 918	8 328 589	530	800 843	R 23 459 904
TOTAL ALL SERVICES	**172**	**6 315 294**	**9 950 094**	**7 560**	**4 151 145**	**R 35 470 200**

Table 8-10: Operations statistics TA3

2.3	TA 3					
Service	No of Services (per w_day)	Estimated Passengers (per w_day)	Scheduled Capacity (per w_day)	No of Vehicles (Optimised, Incl Spares) (per w_day)	Estimated Weekly (Mon-Sun) kilometres (Initial Calcs)	Estimated Income (w_day)
TOTAL IRT	17	3 216 825	1 533 680	3 841	2 575 910	R 17 947 360
TOTAL IRT FEEDER	90	480 910	502 835	2 178	1 111 005	R 2 295 361
TOTAL BUS SERVICES	-	-	-	-	-	R -
TOTAL MINIBUS	11	28 779	38 655	172	83 155	R 192 322
TOTAL RAIL	48	3 355 223	7 771 242	419	701 184	R 18 100 687
TOTAL ALL SERVICES	**166**	**7 081 737**	**9 846 412**	**6 610**	**4 471 254**	**R 38 535 729**

Table 8-11: Operations statistics TA4

2.3	TA 4					
Service	No of Services (per w_day)	Estimated Passengers (per w_day)	Scheduled Capacity (per w_day)	No of Vehicles (Incl Spares) (per w_day)	Estimated Weekly (Mon-Sun) kilometres (Initial Calcs)	Estimated Income (w_day)
TOTAL IRT	16	2 863 120	1 418 090	3 373	2 146 541	R 16 019 188
TOTAL IRT FEEDER	16	142 091	152 460	530	257 581	R 686 278
TOTAL BUS SERVICES	-	-	-	-	-	R -
TOTAL MINIBUS	90	982 059	952 015	2 115	1 378 325	R 7 133 877
TOTAL RAIL	49	3 233 468	7 715 360	403	682 780	R 17 563 391
TOTAL ALL SERVICES	**171**	**7 220 738**	**10 237 925**	**6 421**	**4 465 227**	**R 41 402 734**

Table 8-12: Operations statistics TA5

2.3	TA 5					
Service	No of Services (per w_day)	Estimated Passengers (per w_day)	Scheduled Capacity (per w_day)	No of Vehicles (Incl Spares) (per w_day)	Estimated Weekly (Mon-Sun) kilometres (Initial Calcs)	Estimated Income (w_day)
TOTAL IRT	17	2 972 323	1 525 315	1 889	2 551 807	R 16 504 036
TOTAL IRT FEEDER	83	376 685	393 975	1 746	978 538	R 1 721 739
TOTAL BUS SERVICES	-	-	-	-	-	R -
TOTAL MINIBUS	18	153 774	135 390	947	879 860	R 787 757
TOTAL RAIL	48	3 372 162	5 570 756	334	449 192	R 21 821 263
TOTAL ALL SERVICES	**166**	**6 874 944**	**7 625 436**	**4 916**	**4 859 397**	**R 40 834 795**

It is noted that in all of these alternatives the "Scheduled Capacity" of the road-based modes are lower than the "Estimated Passengers" which is due to the load factor being higher than 1 on most of these services, which indicates that the available seats are used more than once on each journey. This contributes significantly to the viability of the services.

The rail mode indicates a vast oversupply of capacity, which is due to the low off-peak demand on the rail routes without the ability to reduce the capacity of the train-sets to match the reduction in demand. Although this may be practical in theory it is difficult to implement in practise and the reduction in operating costs will be negligible.

8.6 Conclusion

On comparison of all the alternatives it is noted that TA5 has the lowest total operational deficit and will be, from a financial point of view, the alternative that will require the least amount of subsidy to provide an adequate level of service to the majority of residents in the City of Cape Town.

It is also apparent, from the TA5 development, that in order to reduce the reliance on subsidies for public transport operations it is not sufficient just to implement a new network without any operational optimisation, demand headway restrictions and fine tuning of routes using interventions such as, amongst others, express services and radical measures to increase the operational speeds of the services. Extremely important will also be the use of sophisticated scheduling software which will be able to handle numerous services, complicated interlinking, synchronising of transfers between services of all modes, and vehicle sizes.

9. Evaluation of alternatives

9.1 Introduction

The City of Cape Town's continued growth in terms of population, GDP per capita and employment will necessitate transport interventions in the next 20 years. As part of the City of Cape Town's Integrated Public Transport Network (IPTN) project, a strategic assessment was conducted to evaluate five IPTN Alternatives.

A transport demand model was developed as part of the IPTN to test the five network alternatives for different future land use scenarios. The five network alternatives were then evaluated according to the following assessment criteria.

- Environmental Sustainability
- Strategic Transport Assessment
- Social Impact Assessment
- Alignment with corporate plans
- Strategic Economic Assessment

The above assessments were conducted to arrive at the most sustainable and economically feasible Network Alternative by combining these assessments in a Multi Criteria Analysis which is discussed in Chapter 10 of this report

9.2 Environmental sustainability

9.2.1 Interpretation of Scope

A Strategic Environmental Assessment was used to inform the selection of the preferred IPTN alternative from an environmental perspective. The following issues were explored in the Strategic Environmental Assessment:

- Identification of environmental sustainability criteria relevant to the City of Cape Town context;
- Integration of environmental criteria with other specialist fields to avoid duplication and allow for constructive integration; and
- Identification of an appropriate level of impact assessment that matches the strategic level of the IPTN strategy project.

The Strategic Environmental Assessment consists of:

- A set of criteria or indicators that were used to assess network alternatives; and
- The assessment and ranking of alternatives in terms of their relative environmental performance.

9.2.2 *Indicators*

Integration of sustainability objectives
Sustainable transportation can be seen as a transport system with low negative environmental costs yet high positive social value, which supports resource efficient economic development. According to the European Conference of Ministers of Transportation (ECMT, 2004) sustainable transportation therefore:

1. Allows individuals, companies and societies to meet their basic mobility needs in a way that preserves humans and ecosystem health, and promotes equity within and between successive generations.
2. Is affordable, efficient, offers a choice of transport mode and supports a competitive economy, as well as balanced regional development, and
3. Limits emissions and waste within the planet's ability to absorb them, uses renewable resources at or below their rates of generation, and uses non-renewable resources at or below the rate of development of renewable substitutes, while minimizing the impact on the use of land and the generation of noise.

In accordance with the latest update of the Comprehensive Integrated Transportation Plan (CITP) for the CoCT, these principles of environmental sustainability were reduced to three broad themes - ecosystem health, human health and intergenerational equity in environmental quality. These three themes captured the need to ensure a healthy and safe environment for current residents of the City, an ecological system that does not deteriorate over time due to transportation impacts, and the need to use environmental resources such as land, air, water and energy in a sustainable manner.

9.2.3 *Selection of evaluation criteria*

For the purposes of the strategic evaluation of the IPTN, environmental performance criteria or indicators were taken from the sustainability analysis of the CITP. These criteria reflect a locally relevant yet internationally referenced evaluation matrix, and are therefore appropriate for assessment of different IPTN alternatives.

The CITP identifies 12 indicators of environmental sustainability, but for the purposes of the assessment of IPTN network alternatives, not all of the indicators were used. This was either due to some of the impact criteria being manageable on a local, site- or case-specific basis rather than as network wide strategic solutions, or due to some of the indicators already being represented as components of other indicators. The indicators listed in the CITP are:

1. Loss or degradation of threatened biodiversity (Critical Biodiversity Areas)
2. Water pollution (contaminants entering natural water bodies)
3. Air pollution
4. Loss or fragmentation of less sensitive natural areas (e.g. Other Ecological Support Areas)
5. Loss of Other Natural Vegetation and /or open space

6. Energy consumption
7. Greenhouse gas emissions
8. Natural hazards
9. Noise (ambient and specific)
10. Vibration (specific)
11. Visual (incidence and exposure)
12. Heritage (specific)

Table 9-1 below lists indicators that are not relevant for the IPTN evaluation. These include water pollution which is included in assessment of ecosystem health, and the environmental stressors that can be managed at local scale.

Table 9-1: CITP sustainability criteria deemed not relevant to the study

Indicator	Sub-indicators	Motivation
Water pollution such as contaminants entering natural water bodies	Extent of spatial conflict between wetlands and new infrastructure	N/A as wetlands are already included in BioNet categories
	Increase in stormwater contamination due to new infrastructure	N/A as appropriate design can manage site-specific pollution
Noise	Minimise noise exposure	N/A as appropriate design can manage site-specific impacts
Vibration	Minimise vibration exposure	N/A as appropriate design can manage site-specific impacts
Visual	Minimise visual impacts	N/A as appropriate design can manage site-specific impacts and aspect is managed to an extent by protection of biodiversity
Infrastructure as risk from Natural Hazards		N/A as appropriate design can manage site-specific impacts and aspect is managed to an extent by protection of biodiversity

The resultant list of indicators used in assessment of the relative environmental sustainability of the different public transport networks is shown in Table 9-2 below.

Table 9-2: Indicators to be used for the Strategic Environmental Assessment

Indicator	Sub-indicators	Method	Data Requirements
Ecosystem health (biodiversity)			
Loss or degradation of sensitive habitat	Extent of spatial conflict between sensitive ecological spaces and new infrastructure: • Critical Biodiversity Areas (CBA) • Protected & Conservation Areas • Critical Environmental Support Areas (CESA) • Other Environmental Support Areas (OESA)	GIS overlay comparing the CoCT BioNet and new infrastructure	Extent and location of sensitive areas Spatial extent of network as land take, not centerline
Human health (air and water pollution)			
Air pollution	Total emissions: NO_2 & PM	Total expected emissions per vehicle-km: NO_2 & PM	Vehicle-km for different modes and routes Emissions factors
	Direct exposure to air pollution	Comparison between pollution source density and population density	Emissions per mode and route Population density alongside routes
Intergenerational equity in environmental quality (use of non-renewable environmental resources)			
Greenhouse Gases (CO2 emissions per vehicle-km)		Total CO_2 emissions or emissions intensity (per vehicle-km)	Vehicle-km per mode Emissions factors
Energy use		Total energy requirements	Vehicle-km per mode

			Energy conversion factors

9.2.4 *Discussion of selected criteria*

Loss or degradation of sensitive habitat

The Cape Floristic Region has a high proportion of unique and threatened species, and as a result is considered a global biodiversity hot spot. The City of Cape Town has about 3000 native plant species, which is one third of the Cape Flora, within 3% of its area. Eighteen threatened national vegetation types are represented, eleven of which are Critically Endangered. The City also has 331 Red List Threatened and Extinct plant species, which effectively concentrates 13 % of South African threatened species in less than 0.1% of its area.

This poses challenges for creating urban transportation networks that rely on extensive linear infrastructure, since the best chance at conserving the sensitive biodiversity elements and the ecosystem services which they provide lies in maintaining large unfragmented units of the vegetation.

An assessment of the impact on open space elements by different public transport networks is therefore one of the key informants of sustainable network design. Consequently, the comparative assessment evaluated how much conflict exists between the proposed public transport networks and sensitive open space elements. This was done by measuring the extent of sensitive area likely to be compromised in favour of new development for the different network alternatives, and comparing the results.

The City of Cape Town's Biodiversity Network (BioNet) maps were used to indicate areas of sensitivity. Portions of natural vegetation that are considered of importance in the BioNet are designated as Protected Areas, Critical Biodiversity Areas or CBAs, Other Ecological Support Areas (OESA) and Critical Ecological Support Areas (CESA).

Air pollution

Common pollutants contributing to smog in the city are greatly attributed to transportation – 65% of visible pollution is attributed to vehicular emissions (Wicking-Baird, 1997). A breakdown of the different pollutants generated by passenger transport in the City of Cape Town points to private vehicles being significantly more polluting than public transport.

Air pollution is as much determined by the amount of emissions as the type of emissions. All motorised transportation results in emissions, irrespective of the type of vehicle, since even electric vehicles are likely to rely on the conversion of fuels into electricity. Typically, emissions consist of various gases along with small solid particles. The gases all have certain characteristics that make them relatively dangerous in terms of toxicity and global warming potential. Toxicity and aerosol particles affect organic life directly, whilst the global warming potential refers to the relative contribution of a particular gas to the ability of the atmosphere to trap solar radiation. It is an important consideration in urban contexts, since harmful emissions increase the overall burden of disease and places strain on public health systems.

Although a range of different emissions contribute to air pollution, only pollutants with declared emissions standards and a high likelihood of the standards being exceeded are used as indicators of air pollution. The two main pollutants are Oxides of Nitrogen (predominantly Nitrogen Dioxide (NO_2)) and Particulate Matter (PM). The availability of emissions standards means that it is possible to measure performance against a given ambient standard.

Greenhouse Gases (CO_2 emissions per capita)
The transport sector is responsible for 71% of energy consumption in the City of Cape Town (inclusive of aviation and maritime uses) (PGMC, DEADP, 2013). This translates into significant greenhouse gas emissions, totalling 42% of the City's emissions (with maritime and aviation uses included). A modal shift will mean less traffic on our roads, and a substantial reduction in fuel being used. This, in turn, leads to significantly less CO_2 emissions.

A comparison of the relative carbon intensity of the different public transport network alternatives was therefore used as an important measure of sustainability – especially in terms of sustainability going forward into the future, since the transportation network will effectively incorporate built-in carbon efficiencies that may be difficult to alter following implementation.

Energy use
Energy use is a significant determinant of transportation viability and cost-effectiveness. Energy usage is also an important component of climate change mitigation strategies, as transportation is a major consumer of energy and therefore can influence the amount of greenhouse gases being released into the atmosphere. In response, the City has committed itself to energy use efficiency targets, in line with provincial and national policy. With transportation being the sector responsible for the highest energy use in the City, it can be used as a driver of change or flagship sector in the city as a whole should the energy consumption and intensity be lowered over time.

9.2.5 *Data & Assumptions*

Data
The Strategic Environmental Assessment used data generated as part of the IPTN network development process to calculate the relative performance of the different alternative networks. Data used for the different evaluation criteria is indicated in Table 9-3 below:

Table 9-3: Data requirements and sources

Indicator	Data Requirements	Data Sources
Loss or degradation of sensitive habitat	Extent and location of sensitive areas Spatial extent of network as land take, not centerline	CoCT Bionet spatial categorisations (CBA1, CBA2, OESA, CESA, Conservation Areas, Protected Areas (in perpetuity and not in perpetuity) Estimations of space requirements for new transport infrastructure Network layouts

Air pollution	Vehicle-km for different modes and routes Emissions factors	EMME model outputs – veh-km per mode per route Literature review for emissions factors
	Emissions per mode and route Population density alongside routes	Total emissions calculated per mode for previous step EMME model outputs – Population estimations for 2032
Greenhouse Gases (CO2 emissions per vehicle-km)	Vehicle-km per mode Emissions factors	EMME model outputs – veh-km per mode per route Literature review for emissions factors
Energy use	Vehicle-km per mode Energy conversion factors	EMME model outputs – veh-km per mode per route Literature review for emissions factors

Assumptions

Modelling of future transport requirements, vehicular movements, emissions factors and population density necessarily requires certain assumptions to be made as a result of uncertainties related to technological advances and socio-political conditions. The assumptions create uncertainty, but model outputs remain valid if they are interpreted in recognition of the stated uncertainties.

The main assumptions that were used for the environmental assessment are:

- The inputs and outputs used for the EMME model trip calculations as part of the transport demand modelling, including population figures for 2032 at 'sub-place' lev-el, vehicle classifications and demand projections
- Average linear infrastructure width requirements:
    - Trunk routes = 40m
    - Feeder routes = 20m
    - Rail = 50m (due to uncertainty about the exact alignments for proposed lines, a 200m corridor is evaluated and the results reduced by a factor of 4)
- Road and rail infrastructure extensions included in this assessment are those included in the EMME modelling, and specifically for rail:
    - the planned Blue Downs Rail Corridor, which applies to Alternatives TA2, TA3, TA4 and TA5

- the Chris Hani to Firgrove station link, which applies to Alternatives TA2, TA4[15] and TA5

- 2014 emission factors and projections thereof for the year 2032
- The Petrol/Diesel passenger vehicle split is assumed to be 50/50
- For direct exposure to emissions, the study uses an approximation of the number of people expected to be living within 100m of a transport corridor in 2032

Emission factors used are listed in Table 9-4 below:

Table 9-4: Emission factors for 2014

Mode	Data source	Emission Factor	Description of vehicle type
Bus	Default values for TEEMP model under GEF funding	0.6715gPM/km	"No Data" vehicles in Asia
	Default values for TEEMP model under GEF funding	6.178gNOx/km	"No Data" vehicles in Asia
	Rea Vaya calculations	1.293kgCO_2/km	Value for 2014
	UCT SATIM model	84km/Gj	Passenger Bus Oil Diesel
BRT	Default values for TEEMP model under GEF funding	5gNOx/km	Diesel EuroIV
	Default values for TEEMP model under GEF funding	1,1736kgCO_2/km	Value for 2014
	Default values for TEEMP model under GEF funding	0.1gPM/km	Diesel EuroIV
	UCT SATIM model	97km/Gj	Passenger BRT Oil Diesel
Minibus-taxi	Rea Vaya calculations	0.266kgCO_2/km	Value for 2014
	Default values for TEEMP model under GEF funding	0.518gNOx/km	"No Data" petrol vehicles in Asia
	Default values for TEEMP model under GEF funding	0.004gPM/km	"No Data" petrol vehicles in Asia
	UCT SATIM model	220km/Gj	Average between Passenger Minibus Oil Gasoline & Diesel
Train	UCT SATIM model & Eskom reporting on EM	0.017gPM/km	Value for 2012

[15] The necessity of building this rail link is still to be determined by demand, but since the rail servitude has to be secured, it is included in the TA4 calculations.

	Default values for TEEMP model under GEF funding	0.196gNOx/km	Value for 2012
	Default values for TEEMP model under GEF funding	46.42gCO_2/km	Value for 2012
	UCT SATIM model	97km/Gj	Passenger Metro Rail Electricity
Private Car	Default values for TEEMP model under GEF funding	0.4385gNOx/km	Ave for Petrol and Diesel, "No Data" vehicles in Asia
	Default values for TEEMP model under GEF funding	0.0455gPM/km	Ave for Petrol and Diesel, "No Data" vehicles in Asia
	Rea Vaya calculations	0.262kgCO_2/km	Value for 2014
	UCT SATIM model	282km/Gj	Ave for Passenger Car Priv.Veh. Oil Diesel, Passenger Car Priv.Veh. Oil Gasoline, Passenger SUV Priv.Veh. Oil Diesel, Passenger SUV Priv.Veh. Oil Gasoline

Since the network operation was projected for a 20 year time horizon, i.e. the year 2032, the emission factors had to be adjusted to compensate for technological advances, stricter regulatory controls and a shift towards energy sources with better emissions profiles.

Accordingly, the following 'rules' in Table 9-5 were applied to adjust the estimated emissions downwards:

Table 9-5: Emission assumptions

Increased efficiency of new Metrorail rolling stock (X'Trapolis Mega from Alstom)	– 31% improvement
ESKOM shift from coal based energy generation to renewable or clean energy sources (comparison between current and future energy generation mix described in the 2013 IRP update)	– 50% improvement
Assumed 10% of new BRT fleet shift from liquid fuels to electricity (i.e. 10% achieve a 50% improvement)	– 5% improvement
Any new BRT vehicles (assumed 10% of fleet) achieve 50% improved road based vehicle emissions standards (EURO 4/5 to EURO 6 and beyond)	– 5% improvement
Any new bus and minibus-taxi vehicles (assumed 50% of fleet) achieve 50% improved road based vehicle	- 25% improvement

emissions standards (EURO 3 to EURO 6 and beyond)	
Private vehicles (assumed 50% of fleet) achieve 50% improved road based vehicle emissions standards (EURO 3 to EURO 6 and beyond)	- 25% improvement

As a consequence of this compound 'discounting', emission factors were adjusted for the 2032 horizon as follows:

- Rail emissions reduced by 65.5%
- BRT emissions reduced by 9.8%
- Bus & Taxi emissions reduced by 25%
- Private car emissions reduced by 25%

9.2.6 *Description of IPTN Alternatives*

The five network which were evaluated (for the year 2032) are described with assumptions made as follows (
Table 9-6):

Table 9-6: Description of the IPTN alternatives evaluated

	Network alternative	Description	Assumptions/Quantification
TA1	Do minimum	Expanded fleets for MyCiti, improved rolling stock for Metrorail, improved GABS vehicle standards	Pragmatic Transit Orientated densification conditions
TA2	Rail Dominant with limited BRT	As for TA1, but Rail focused with a number of BRTtrunk routes and supporting feeders	Pragmatic Transit Orientated densification conditions
TA3	Limited Rail with more BRT	As for TA1, but only Blue Downs new rail and more BRTtrunks with supporting feeders .	Pragmatic Transit Orientated densification conditions
TA4	1st refined Alternative	A 'best-of-both' scenario of TA2 and TA3 whilst considering financial sustainability (through unscheduled services).	Pragmatic densification conditions
TA5	2nd refined Alternative	Similar to TA4, but focusses on reducing the peak Level of Service to minimise the operational deficit	Pragmatic densification conditions

9.2.7 *Comparison of alternatives*

At the core of the Strategic Environmental Assessment lies the comparison of different public transport network alternatives in terms of their relative environmental performance. Each alternative was measured against the identified environmental sustainability indicators, and the results interpreted for further application in a multi-criteria analysis that integrates environmental performance with social, transport planning and economic performance. The purpose of this assessment is to inform / guide decision making by providing clear descriptions in terms of the level of impacts and best practice considered per alternative thereby highlighting what should be the preferred alternative.

According to the method outlined above, the different IPTN alternatives generate the scores as set out in the following sections.

Loss or degradation of sensitive habitat
With buffers added to the different IPTN routes, a spatial indication of overlap with sensitive areas was generated. According to this, TA5 (2nd refined Alternative) has the greatest overlap with the BioNet:

Table 9-7: Potential conflict between IPTN expansion and ecologically sensitive areas

BioNet category	Protected Area	CBA1	CBA 2	CESA	OESA	Total
TA1						
Rail (50m buffer)						
Trunks (40m servitude)	86.95	33.99	1.17	5.43	3.69	131.23
Totals (ha)	86.95	33.99	1.17	5.43	3.69	131.23
TA2						
Rail (50m buffer)	1.15	14.26			7.67	23.07
Trunks (40m servitude)	95.50	59.74	20.27	5.75	9.16	190.43
Totals (ha)	96.64	74.00	20.27	5.75	16.83	213.50
TA3						
Rail (50m buffer)	0.58	4.74				5.33
Trunks (40m servitude)	165.21	82.49	39.91	6.32	19.19	313.13
Totals (ha)	165.80	87.24	39.91	6.32	19.19	318.46

BioNet category	Protected Area	CBA1	CBA 2	CESA	OESA	Total
TA4						
Rail (50m buffer)	1.15	14.26			7.67	23.07
Trunks (40m servitude)	109.30	77.96	38.68	6.00	14.16	246.10
Totals (ha)	110.45	92.22	38.68	6.00	21.82	269.17
TA5						
Rail (50m buffer)	1.15	14.26			7.67	23.07
Trunks (40m servitude)	165.21	82.49	39.91	6.32	19.19	313.13
Totals (ha)	166.36	96.75	39.91	6.32	26.85	336.20

Air pollution
Two aspects were considered in terms of air pollution – total emissions, and exposure to emissions.

In terms of total pollution, TA1 fared worst, but TA2 and TA4 had higher direct exposure rates:

Table 9-8: Comparison of alternatives in terms of air pollution

Air pollution	Total emissions: NOx	kt	3 166.4	2 590.3	2 347.9	2 392.9	2 226.7
	Total emissions: PM	kt	200.9	146.4	128.1	132.6	125.7
	Exposure to NOx	g/person	0.021	0.239	0.204	0.212	0.194
	Exposure to PM	g/person	0.000	0.000	0.011	0.012	0.012

Greenhouse Gases
The release of carbon dioxide and other greenhouse gases is measured as CO_2eq (Carbon Dioxide equivalent), and again, TA1 showed the worst score:

Table 9-9: Comparison of alternatives in terms of greenhouse gas emissions

Greenhouse	tCO2eq	1 723.6	1 471.7	1 291.5	1 348.7	1 264.1

Gases						

Energy use

The use of energy is measured in Gigajoules consumed, and for the morning peak hour, TA 1 fared worst, with TA2 next in line.

Table 9-10: Comparison of alternatives in terms of energy use

Energy consumption	GJ	24 738.2	20 978.7	18 244.5	19 258.4	18 020.4

9.2.8 *Summary of findings*

The environmental sustainability framework evaluation shows that TA1 (Do minimum) and TA5 (2nd refined Alternative) are diametrically opposed in terms of negative environmental impacts. TA1 is likely to degrade the environment in terms of total pollution and climate change/energy use impacts, whilst TA5 ranks highest in terms of the impact on natural vegetation and directly exposing people to raised concentrations of particulate matter.

Table 9-11: Summary of environmental performance scores

			TA1	TA2	TA3	TA4	TA5
Indicator	**Sub-indicators**	**Unit**	**Value**	**Value**	**Value**	**Value**	**Value**
Ecosystem health (biodiversity)							
Loss or degradation of sensitive habitat	Extent of spatial conflict between sensitive ecological areas and new infrastructure	hectare	131.2	213.5	318.5	269.2	336.2
Human health (air and water pollution)							
Air pollution	Total emissions: NOx	kt	3 166.4	2 590.3	2 347.9	2 392.9	2 226.7
	Total emissions: PM	kt	200.9	146.4	128.1	132.6	125.7
	Exposure to NOx	g/person	0.021	0.239	0.204	0.212	0.194
	Exposure to PM	g/person	0.000	0.000	0.011	0.012	0.012
Intergenerational equity in environmental quality (use of non-renewable environmental resources)							
Greenhouse Gases		tCO2eq	1 723.6	1 471.7	1 291.5	1 348.7	1 264.1
Energy consumption		GJ	24 738.2	20 978.7	18 244.5	19 258.4	18 020.4

In order to reduce the complexity of this rating further for the purposes of using the ratings for the five main criteria in a larger multi-criteria analysis along with other strategic assessments, the values for total emissions and exposure are combined to give a single value to each criterion. This was done on the basis of comparing the relative health risk emanating from oxides of nitrogen and particle emissions. According to World Health Organisation standards adopted in South Africa, the level of particle emissions considered acceptable as ambient atmospheric concentration is approximately 2,7 times lower than for nitrogen dioxide, and therefore weight-by-weight, 2,7 times more important. By implication, the effective Total Emissions and Exposure scores are derived by combining the values as 1x NOx and 2,7x PM.

The final ranking of the five IPTN Alternatives as determined from an environmental perspective is shown in Table 9-12:

Table 9-12: Final IPTN Alternative Environmental Rankings

Indicator	Unit	TA1	TA2	TA3	TA4	TA5
Loss or degradation of sensitive habitat	hectare	131	213	318	269	336
Air Pollution: Total Emissions	kt (NOx eq)	3769	3030	2732	2791	2604
Air Pollution: Exposure	g/person (NOx eq)	0.02	0.24	0.24	0.25	0.23
Greenhouse Gases	tCO2eq	1724	1472	1291	1349	1264
Energy consumption	GJ	24738	20979	18245	19258	18020

This results in TA5 ranking as preferred alternative, with TA1 scoring lowest.

The poor showing of TA5 in terms of impact on Biodiversity should be investigated in terms of how and where the planned new rail corridors and BRT trunk routes are planned, whilst the elevated levels of air pollution next to main transport corridors require attention in terms of reducing the emissions from vehicles.

9.3 Strategic Transport Impact Assessment

9.3.1 Background

It was initially suggested to evaluate seven subject areas for the purposes of the Strategic Transport Impact Assessment. After discussion with city officials and evaluation of all assessment criteria (environmental, economic, social, transport and alignment with corporate strategies), it was decided to use only four criteria for the strategic transport assessment. The seven initial criteria are discussed below.

Modal Split
The transport network alternatives result in different assignments to private and public transport trips. The results for the future were compared with each other and with the status quo. The consequence of possible increased usage of public transport is indicated for each mode. This criterion was selected as one of the final four to be used for the transport assessment.

Impact on TCT
The consequences of possible increased public transport usage on the staffing, financing and managing of TCT were assessed at a strategic level. For example, how large will the newly created IRT Section have to become, should the IRT service be expanded over a number of corridors. Some consideration of roles/responsibilities of other existing transport organisations (public and private) was done, but it has to be acknowledged that this is a complex matter which will eventually only be resolved through extensive negotiations with all parties. This criterion was eventually excluded from the analysis.

Construction of Roads
Identical road construction programmes were considered to apply for all the future transport scenarios. As a result, this criterion was not used in the assessment.

Traffic Operation
The performance of the road networks (also in relation to the current network) for the future scenarios could have been assessed using a number of performance indicators, including:

- Km of road with V/C >1.0;
- Average travel times and travel speeds (both private and public transport);
- Total vehicle-km of travel;
- Duration of congestion;
- Per cent of network congested, and
- Fuel consumed and greenhouse gas emissions (which was included in the environmental assessment).

Eventually three of the above criteria were selected for evaluation in the transport assessment, namely (i) total vehicle-km of travel for each mode, (ii) the kilometre of road with a v/c >1.0 and (iii) the average travel time per mode.

Non-Motorised Transport
Pedestrian movement was not modelled in the EMME2032 demand model, but some qualitative assessment of the integration of the NMT Master Plan with the future network scenarios could be done at a coarse level. This criterion was eventually excluded from the transport assessment.

Freight Movement
Some assessment of the impact of the public transport network proposals on freight movement could have been performed. As this was not done as part of this exercise, this criterion was eventually excluded from the transport assessment.

Disaster and Incident Management
Normally this criterion indicates any specific disaster and incident management advantages associated with the future scenarios. This criterion was eventually excluded from the transport assessment because it would be applied in the same way to all network alternatives..

9.3.2 *Selected Criteria*

After work shopping with City officials, four criteria were selected for the strategic transport assessment. These criteria are summarised in Table 9-13.

Table 9-13: Summary - Strategic Transport Assessment Criteria

Criteria Name	Criteria Detail	Reasoning for measuring this item	What is this item comprised of (i.e. input)	Assumptions	What is the output	What are reasonable results
Modal split (public transport users vs total transport users)	Total trips on public transport and NMT, versus total number of trips being undertaken	The objective of the City is to maximise the public transport modal split to relieve congestion and to increase public transport ridership to increase the financial viability of the system (operational cost coverage).	Output from EMME model	Exclude all intra zonal trips. All trip purposes. AM peak hour	Total number of trips on public, private and NMT.	A reasonable cut-off modal split is considered 60/40 (trips to CBD on daily basis), i.e. private 60% and public transport 40%. The province has a strategic objective of a 13% modal shift by 2014 (accurate measuring remains a challenge).
Total vehicle-km per mode	Total vehicle-km of travel on each of the modes	Objective to minimise the total vehicle kilometres travelled per mode.	Output from EMME model	Exclude all intra zonal trips. All trip purposes. AM peak hour. All modes will be compared.	Total vehicle-km per mode	Depends on output of model
V/C ratio	Km of road with volume/capacity >1.0	Transport Alternative with a lower % of road with a volume/capacity ratio of >1.0 is preferred	Output from EMME model	N/A	The output will be km of road with v/c >1.0	Depends on output of model
Average travel time	Average travel time on different modes, road and rail	The CoCT ITP have the following objective: operating speed of between 30-50 km/h and that 80% of passengers should not travel more than 60 minutes	Output from EMME model	Use the travel time from each centroid connector of the TZ to another TZ. AM peak hour travel times. All modes	Average operating speed per mode will be used together with average trip length by mode to determine average travel time by mode.	Stated CoCT objective will be used as a guide, but a reasonable result will depend on the output of the model.

9.3.3 *Performance of Transport Alternatives*

The EMME modelling results of the base year and five selected future scenarios were used.

Modal Split

The EMME results for the number of persons using the different modes for the base year, as well as the five future scenarios (complete Cape Town Metropolitan area), are summarised in Table 9-14. Note that this table includes the number of person trips with the "main mode", whereas the table in the earlier section represents all person trips per mode, which, due to transfers, are not the same as the persons per main mode.

Table 9-14: EMME Results (Number of person trips by main mode)

Mode	Total Modal Split (Peak Period)											
	BASE		TA1		TA2		TA3		TA4		TA5	
Walk	111 408	8%	103 332	5%	102 795	5%	102 795	5%	102 795	5%	102 795	5%
Private Vehicle	742 785	53%	1 096 034	53%	1 107 962	54%	975 189	47%	989 790	48%	975 189	47%
Minibus Taxi	213 908	15%	331 685	16%	10 987	1%	5 068	0%	115 765	6%	5 068	0%
Contracted Bus	148 741	11%	213 514	10%	1 228	0%	1 244	0%	1 242	0%	1 244	0%
MyCiti	1 664	0%	39 936	2%	425 215	21%	661 254	32%	542 026	26%	661 254	32%
Rail	184 015	13%	269 430	13%	406 362	20%	308 999	15%	302 930	15%	308 999	15%
Total	1 402 520	100%	2 053 930	100%	2 054 549	100%	2 054 550	100%	2 054 549	100%	2 054 550	100%

Mode	Total Modal Split (Peak Hour)											
	BASE		TA1		TA2		TA3		TA4		TA5	
Walk	41 051	6%	42 292	4%	41 992	4%	41 992	4%	41 992	4%	41 992	4%
Private Vehicle	330 672	47%	522 975	48%	534 973	54%	473 163	49%	481 348	49%	473 163	48%
Minibus Taxi	129 780	18%	199 260	18%	5 615	1%	2 293	0%	69 520	7%	21 092	2%
Contracted Bus	97 894	14%	141 143	13%	739	0%	752	0%	751	0%	752	0%
MyCiti	786	0%	16 415	2%	166 607	17%	259 972	27%	214 867	22%	258 776	26%
Rail	102 586	15%	156 851	15%	246 201	25%	184 332	19%	179 297	18%	184 332	19%
Total	702 768	100%	1 078 936	100%	996 127	100%	962 503	100%	987 775	100%	980 107	100%

There are small differences between the results of the peak hour and the peak period, but the general pattern is similar. The following can be concluded:

An increase of approximately 54% in the number of commuters during the morning peak hour between the base year and 2032 is predicted (TA1). This results from the land use and work opportunities input into the model. The modal split for TA1 remains pretty much the same as the base year, which should be expected from the assumptions used. The numbers of people walking stays at the same level between now and 2032, implying a lower percentage of people walking in 2032. This is considered unlikely.

The investment in rail upgrading (TA2), as well as in IRT services (TA3, TA4 and TA5), do lead to substantial higher usage of these services, but it is mostly users of the present minibus taxi and contracted bus services who are shifting to rail and IRT. The percentage of persons in private vehicles increases slightly in the case of TA2, and stays approximately as at present for TA3, TA4 and TA5. The mode shift on private travel in all cases is predicted to be between 1% and 5%.

From a modal split viewpoint, the alternatives are ranked from best to worst as follows in Table 9-15 (1 is best, 5 is worst):

Table 9-15: Ranking of Alternative according to vehicle km travelled for all modes in the AM peak hour

Alternative	TA1	TA2	TA3	TA4	TA5
Rank	4	5	1	3	2

9.3.4 *Vehicle-km per Mode*

The EMME results for the kilometres of travel by each mode, as well as the travel times per mode, for the five future scenarios (total Cape Town Metropolitan area), are summarised in Table 9-16 and illustrated in Figure 9-1. The numbers in the table refer to the peak hour.

Table 9-16: EMME Results (kilometres travelled per mode)

	Vehicle km (AM Peak Hour)				
Alternatives	**TA1**	**TA2**	**TA3**	**TA4**	**TA5**
Private Vehicle	7 996 602	7 232 494	6 204 671	6 512 423	6 254 308
Rail	15 794	20 103	16 507	16 345	16 507
Minibus taxi	334 844	7 419	1 218	92 383	4 871
MyCiTi Trunk	1 751	26 698	52 350	43 309	48 162
MyCiTi Feeder	1 648	18 221	14 961	4 150	11 670
Contracted Bus	84 175	-	-	-	-
Total Vehicle km	**8 350 638**	**7 304 935**	**6 289 707**	**6 668 610**	**6 335 518**

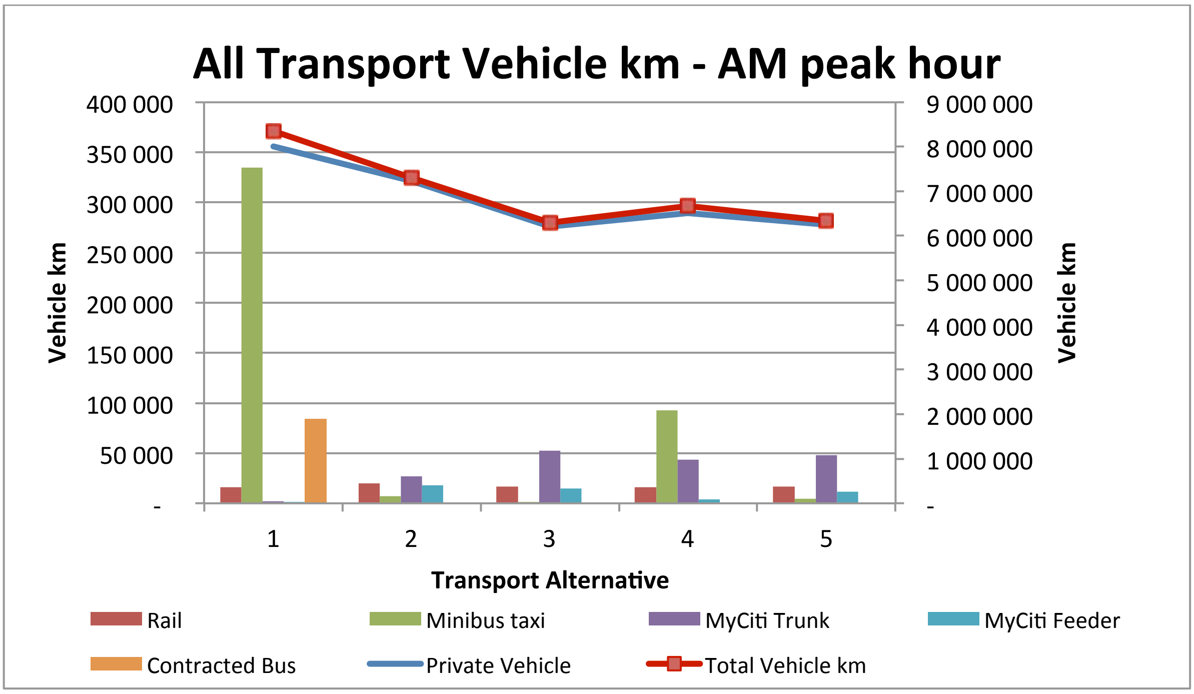


Figure 9-1: All Transport Vehicle km - AM peak hour

With respect to the vehicle-km of travel per mode, the following can be concluded:

For the private vehicle travel, the vehicle kilometres relatively to the base year increase as follows:

- TA1 – almost doubles
- TA2 – approximately 1.8 times more
- TA3 – approximately 1.5 times more
- TA4 – approximately 1.6 times more
- TA5 – approximately 1.5 times more (as for TA3).

From a private travel viewpoint, TA3 and TA5 are preferable. It is however not possible to quantify the effect of capping the supply of services in the peak on the shift from public transport to private transport in TA5. This however should be kept in mind when analysing the results.

i) For rail, the vehicle kilometres increase approximately fourfold for TA2, and approximately threefold for TA1, TA3, TA4 and TA5. Substantial investment in infrastructure, rolling stock and operational cost will be required for all five future scenarios.

ii) For minibus taxis there is a dramatic reduction in vehicle kilometres for TA2, TA3 and TA5, whilst TA4 also shows a strong reduction. Whether these reductions, which in effect imply the termination of minibus taxi services, are possible in practice, is difficult to say. There are positive and negative transport consequences to reduced minibus taxi services. The largest negative consequence is the fact that these services, which are almost unsubsidised at present, will be replaced by services which will have to be subsidised. This means an additional financial liability for tax payers. On the positive side, it can be argued that less minibus taxis will mean more order in the public transport arena, and also an improvement in road safety. From a transport viewpoint, TA2, TA3 and TA5 are preferred with TA4 following close behind and TA1 doing the poorest.

iii) For the contracted bus services, an increase of approximately 30% in vehicle kilometres is predicted for TA1, whilst the service is terminated for TA2 to TA5. From a level of service viewpoint, the latter four alternatives should be preferred (it is assumed that the present contracted bus services will be replaced by higher standard MyCiTi and rail services). From other viewpoints, such as operational cost and subsidy requirements, TA1 might be preferable, as it will require lower levels of subsidies.

iv) For the MyCiTi services, a very high increase in passenger kilometres are predicted for TA3, TA4 and TA5 (approximately 300 times the present number, if both trunk and feeder veh-kms are considered). For TA1 a modest 17 times increase is predicted and for TA2 an approximate 200 times increase. From a level of service viewpoint, the latter three alternatives should be preferred. From other viewpoints, such as operational cost and subsidy requirements, TA1 and TA2 might be preferable.

From the perspective of vehicle kilometre of travel by the different modes, TA3 to TA5 are considered preferable, with TA2 in second place and TA1 in third place (see Table 9-17.

Table 9-17: Ranking of Alternative according to vehicle km travelled for all modes in the AM peak hour

Alternative	TA1	TA2	TA3	TA4	TA5
Rank	5	4	1	3	2

9.3.5 *Volume/capacity (v/c) ratio*

The number and percentage of road links with a volume/capacity ratio of more than one for the future scenarios are shown in Table 9-18

Table 9-18: Number and Percentage of Road Links with Volume/Capacity > 1

SCENARIO	NO. OF NETWORK LINKS	DEGREE OF SATURATION		
		No. > 1.0	%	km
TA1	23301	1643	7%	945
TA2	23301	3003	12%	1606

TA3	23301	1767	7%	1093
TA4	23301	2111	9%	1270
TA5[16]	23301	1767	7%	1093

It is clear that the number of links with a v/c >1 for TA1 is less than those of TA2 to TA4. Although all future transport alternatives have the same future road network, one should expect that TA1 would have the higher degree of saturation. However, the reason for TA1 being the most favourable alternative when looking at the number of links with a V/C higher than 1.0, is due to more extensive peak spreading for TA1. Table 9-14 indicates that TA1 has the lowest percentage private vehicle passengers in the AM peak hour which does not significantly differ from TA3-TA5. TA1 is preferable from a strategic transport viewpoint. The V/C plot for private vehicles for all four Transport Alternatives are indicated below in Figure 9-2 to Figure 9-5 from Table 9-18 above.

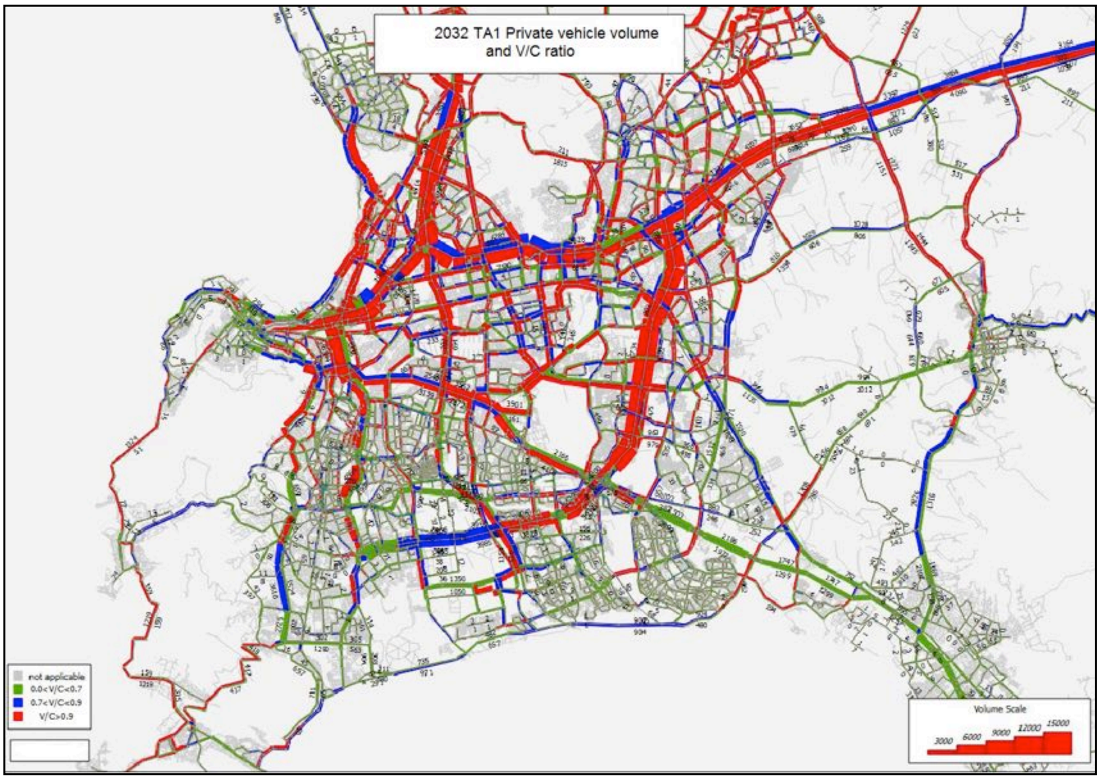


Figure 9-2: 2032 TA1 Private Vehicle volume and V/C ratio

[16] TA5 was not modelled and the saturation levels are considered to be the same as TA3.

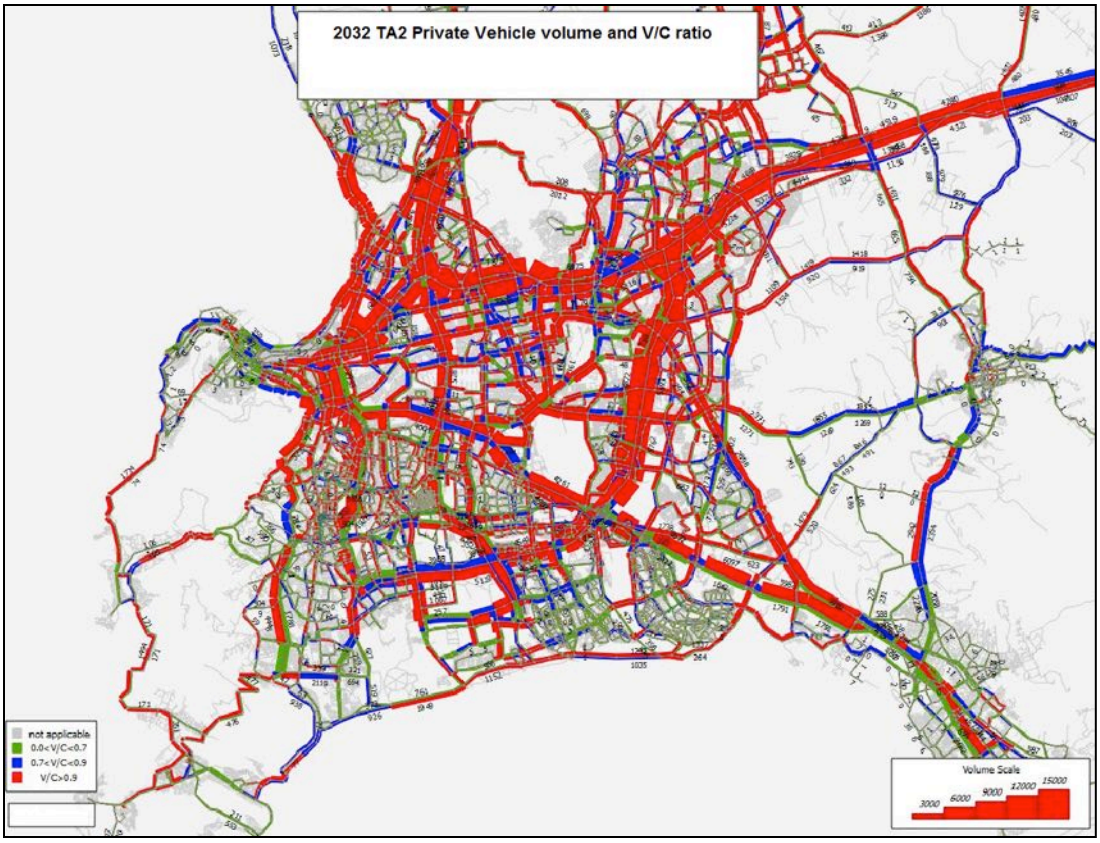


Figure 9-3: 2032 TA2 Private Vehicle volume and V/C ratio

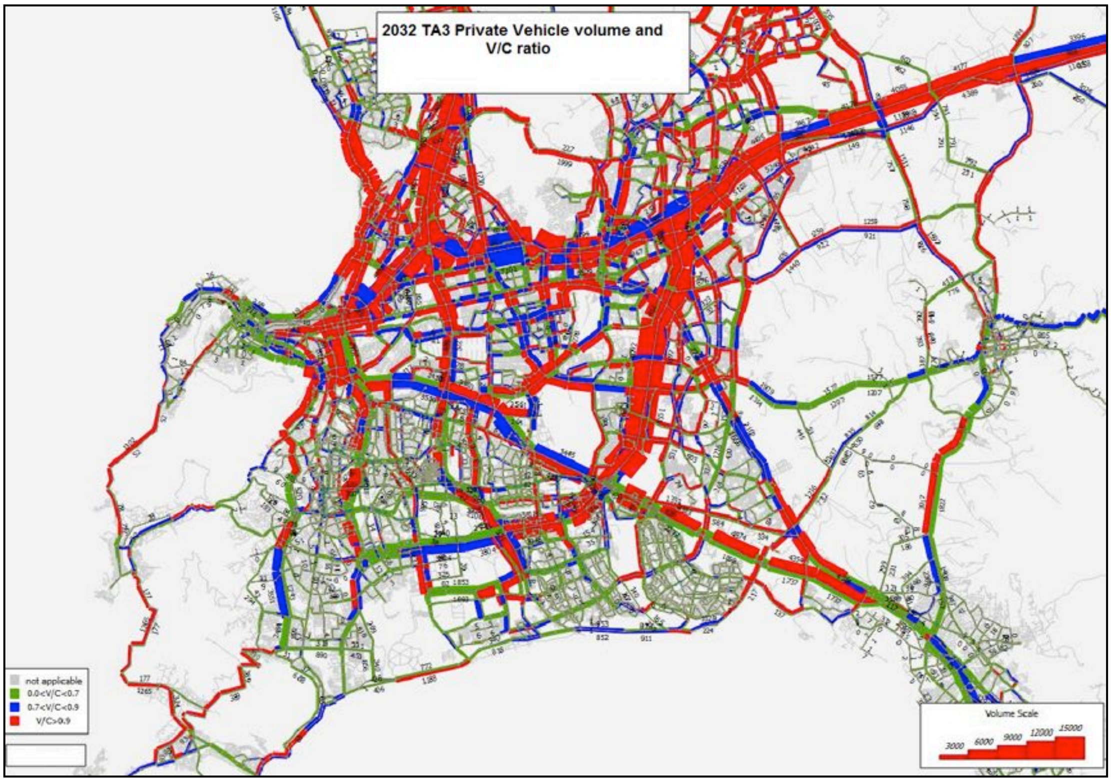


Figure 9-4: 2032 TA3 Private Vehicle volume and V/C ratio

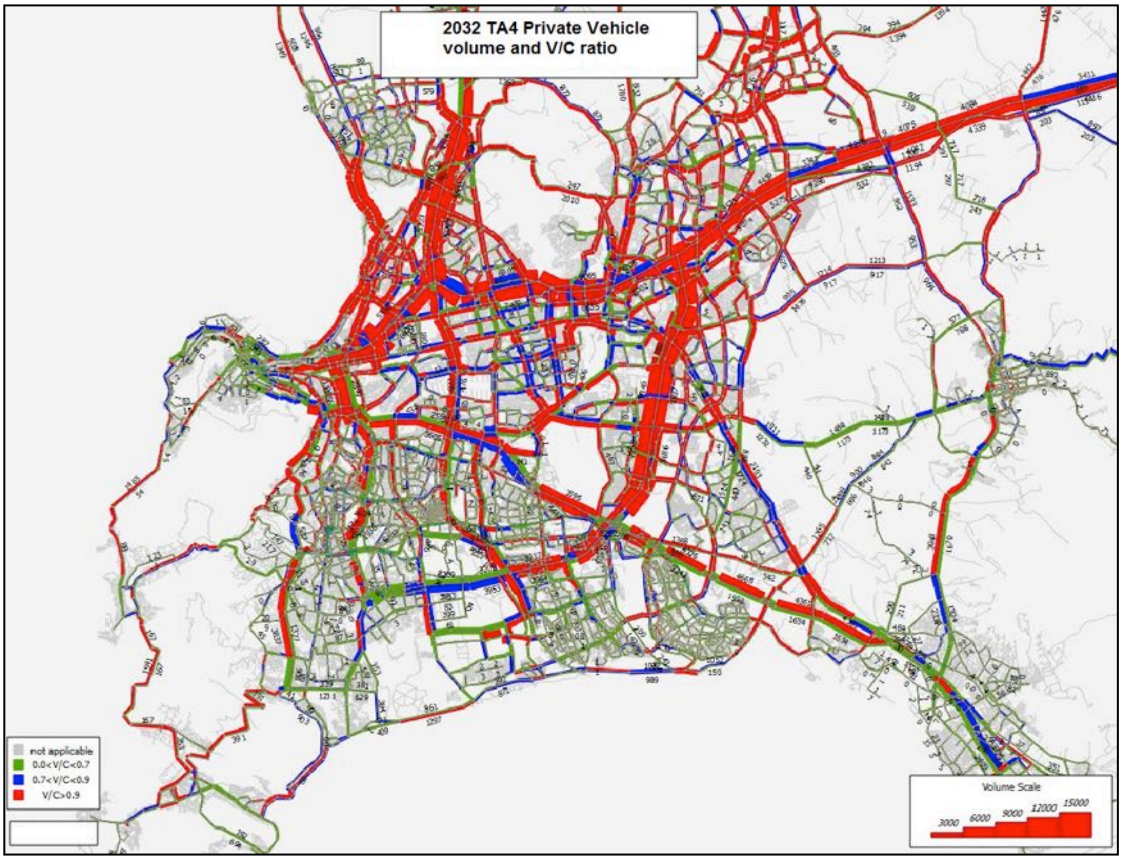


Figure 9-5: 2032 TA4 Private Vehicle volume and V/C ratio

9.3.6 *Average Travel Time*

Based on the model outputs for the AM peak hour period, the average travel times for the different modes are as shown in Table 9-19. Note that for private cars an average vehicle occupancy of 1.5 persons/vehicle was accepted. For the other modes the passenger hours and the number of passengers boarding were used to determine average time spent on the mode per passenger (or average trip length).

Table 9-19: Average Travel Times (per different mode)

	BASE	TA1	TA2	TA3	TA4	TA5
	(trip length in minutes)					
Private car	33.0	340.7	308.2	290.7	315.2	290.7
Rail	24.7	33.8	21.3	20.9	21.1	20.9
Minibus taxi	13.7	14.2	29.1	13.3	21.6	13.3
Bus	20.8	22.1	-	-	-	-
MYCITI	20.1	25.4	29.9	26.1	28.5	26.1

The following can be concluded from the summarised data:

1. The average travel times for the private car for all future scenarios do not appear realistic, as the average trip time is around five hours. This is due to the model not assigning people to private network to satisfy demand (unconstraint model assignment). Due to the fact that the private network is already congested in 2013, the additional private road traffic will result in extreme congested road sections.
2. For the rail mode the average trip time increases by almost 50% for TA1, and reduces slightly for all other future scenarios.
3. For the minibus taxis it is predicted that the trip time will stay approximately the same as at present, except for TA2 where the trip time is approximately double that of the other and TA4 where it is approximately 50% longer.
4. For the contracted bus service, the average travel time for TA1 is approximately the same as the base year. The contracted buses have been excluded in TA2 to TA5.
5. For the MyCiTi it is predicted that the average travel time will increase between approximately 25% and 50% above the base year value. The best travel times are achieved by TA1, TA3 and TA5.
6. Based on these results it is clear that TA3 and TA5 perform the best, with TA2 and TA4 slightly worse and TA1 the worst.

9.4 Social Impact Assessment

9.4.1 Background

Introduction
This is a macro level assessment and is based on a comparative assessment of a number of criteria for each of the five transport networks. Due to the nature of the process, the fact that no public consultation has as yet been implemented and the high level of conceptual mapping, no quantitative verification was possible.

The social assessment criteria are as follows:

- *Resettlement:* For the purposes of this report, this is defined as the involuntary resettlement that may be caused by any of the transport scenarios. Involuntary resettlement has a number of significant negative social impacts and may infringe on a variety of direct or devolved rights as well as particular human right requirements, some of which are indicated in the South African Constitution.
- *Expropriation:* In this case, expropriation is defined as taking possession of land for the purposes of the project. It is usually a process whereby the landowner is compensated for the loss of some or all the land. Expropriation becomes a significant social impact where the loss of such land has a significantly detrimental impact on the ability of such landowner and inhabitants to live their lives according to their needs and social requirements. Where a small piece of land is expropriated and compensated, with little impact on social, economic and cultural uses thereof, it is not deemed a significant negative social impact.
- *Jobs created*: Jobs created in the context of this section, would focus on whether more job opportunities are created as a result of a particular transport scenario. This factor is to a large extent based on assumptions on anticipated macro level job opportunities. It is not possible to quantify this criterion without extensive consultation and focussed research.
- *Linkages to intermodal transport facilities:* This criterion considers optimising access and utilisation of the urban network. Such optimised linkages can facilitate access to social and economic opportunities for all, from a broader serving base, than is currently the case.
- *Linking residential areas and economic, industrial and commercial hubs:* An integrated, affordable, reliable and safe transport network will enhance the "Inclusive City" approach by providing evenly distributed access to economic, commercial and trade opportunities. This linking supports the Urban Network Strategy by improving linkages, via the various interlinked networks and nodes, to the public, including currently excluded

job seekers to other opportunities that were traditionally inaccessible due to access, distance and affordability constraints.

- *Linking residential areas to social services and facilities, including health, education, security and leisure:* Municipal residents need access to sufficient, evenly distributed amenities. Such access will enhance public access to social, services and facilities. This will improve the utilisation of these facilities with wider associated community benefits and is in line with the "Inclusive City" approach.

Assumptions
This assessment based on a number of assumptions. It is assumed that:

- Each network alternative is standalone and considered as such. This implies that the scenario parameters are considered reasonably robust, and little inter scenario passenger and traffic overflow will take place.
- The various factors indicated, (including scaling down of municipal bus services, replacement of feeder network with unscheduled private sector services, control of taxis routes) are effectively in place and realistic.
- Station facilities, specific intermodal facilities, will be placed at optimum locations.
- Within broad corridors, the alignment will be designed to maximise the access to community, commercial, industrial and services infrastructure.

9.4.2 *Comparative Assessment*

This section compared the various scenarios, ranging from TA 1 to 5, in terms of the identified social criteria.

Avoid Resettlement
It was assumed that no additional land would be required in settlements or residential areas, as the trunk route developments will take place within the existing road reserves, or corridors already zoned as such. This led to the conclusion, verified by the planning team, that no resettlement is planned or anticipated as a result of any of the respective transport scenarios.

Table 9-20: Comparative assessment - Avoid Resettlement

Criteria	TA 1	TA 2	TA 3	TA 4	TA 5
Avoid resettlement.	0	0	0	0	0

This criterion was not considered to have an impact on any of the transport scenarios.

Avoid Expropriation

It was assumed that most, if not all, of the transport scenarios were planned to take place within existing road reserves, or would utilise land already zoned as such. This led to the conclusion, that little if any expropriation is foreseen. Expropriation may become an issue during the detail design phases, but at this level the potential impact is deemed insignificant across all the transport scenarios.

Table 9-21: Comparative assessment - Avoid Expropriation

Criteria	TA 1	TA 2	TA 3	TA 4	TA 5
Avoid expropriation.	0	0	0	0	0

This criterion is not considered to have an impact on any of the transport scenarios.

Linkages to Intermodal Transport Facilities

As indicated before, this criterion considered the level to which the different transport networks and modes of transport are interlinked. From this perspective, the transport scenarios were compared at a macro level in terms of intermodal linking. The more numerous and efficient intermodal integration, the better the comprehensive access and utilisation of the urban network.

Figure 9-6 to Figure 9-11 indicate a comparison of the trunk routes (rail and BRT) and the feeder network for the respective alternatives.

Figure 9-6: TA 1

Figure 9-7: TA 2

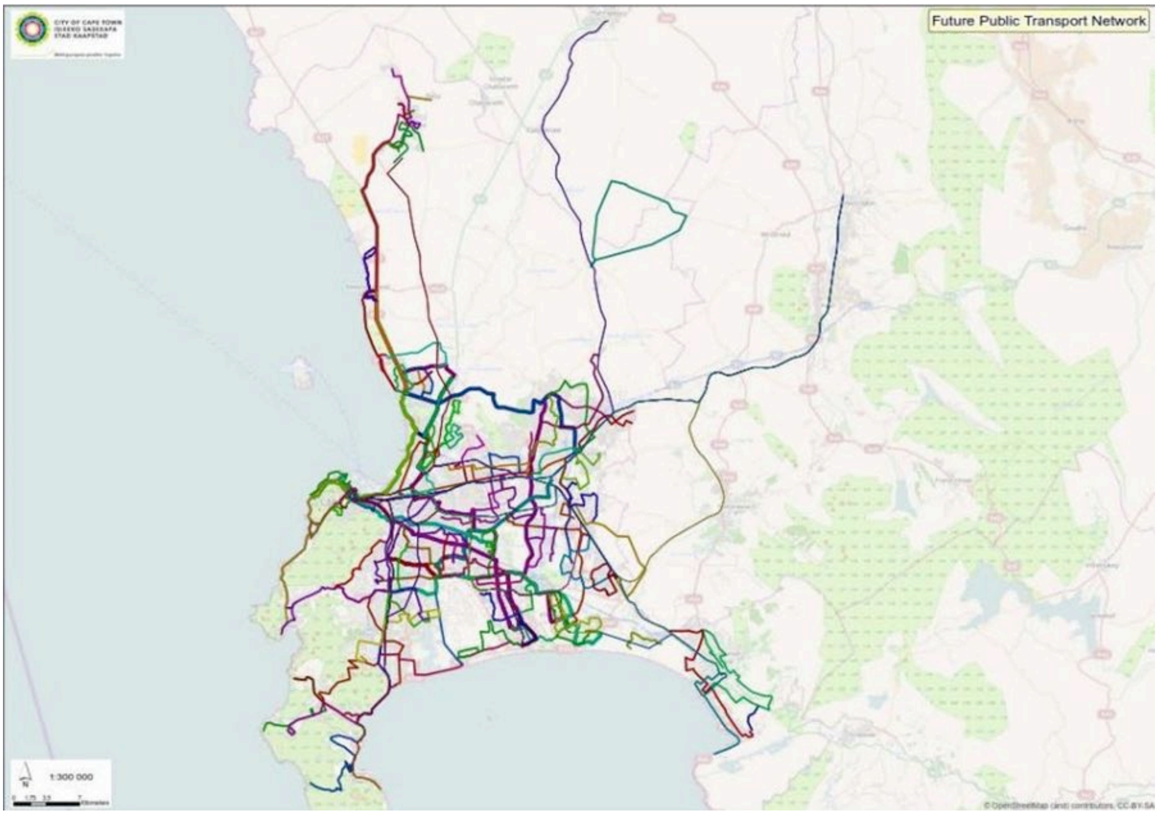


Figure 9-9: TA 3

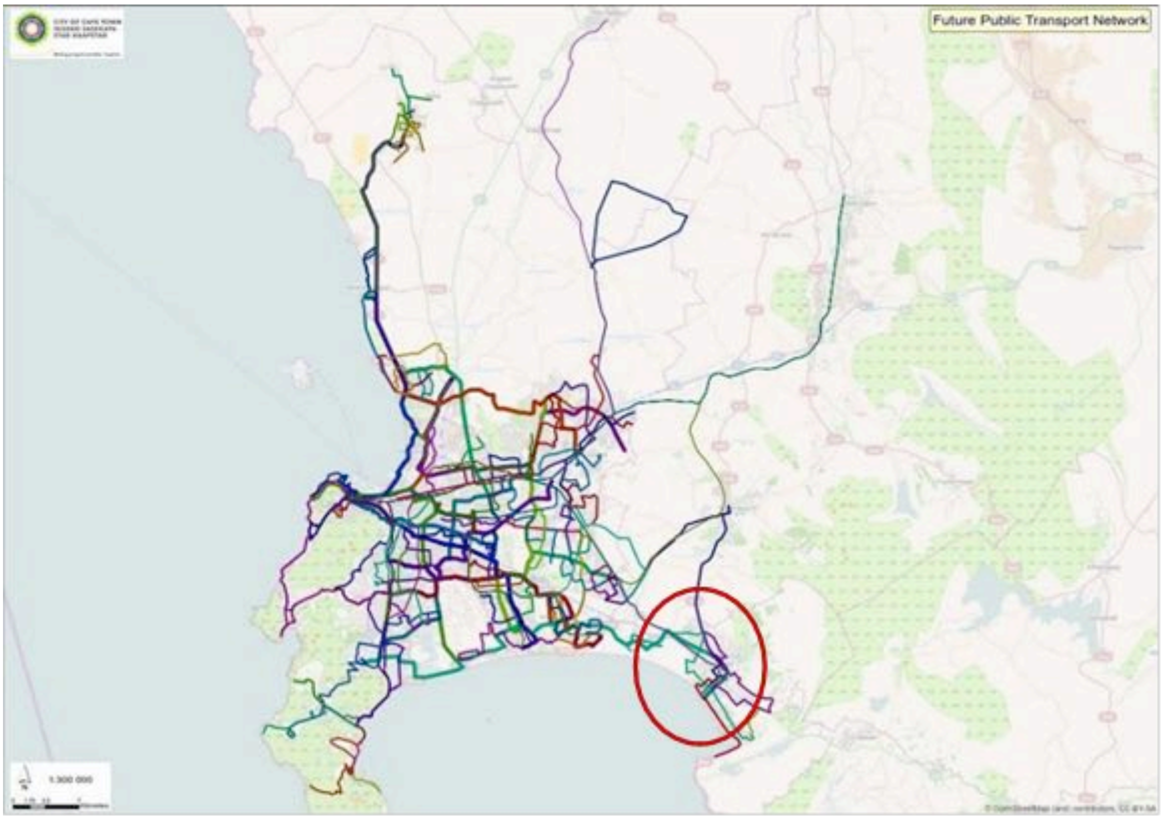


Figure 9-10: TA 4

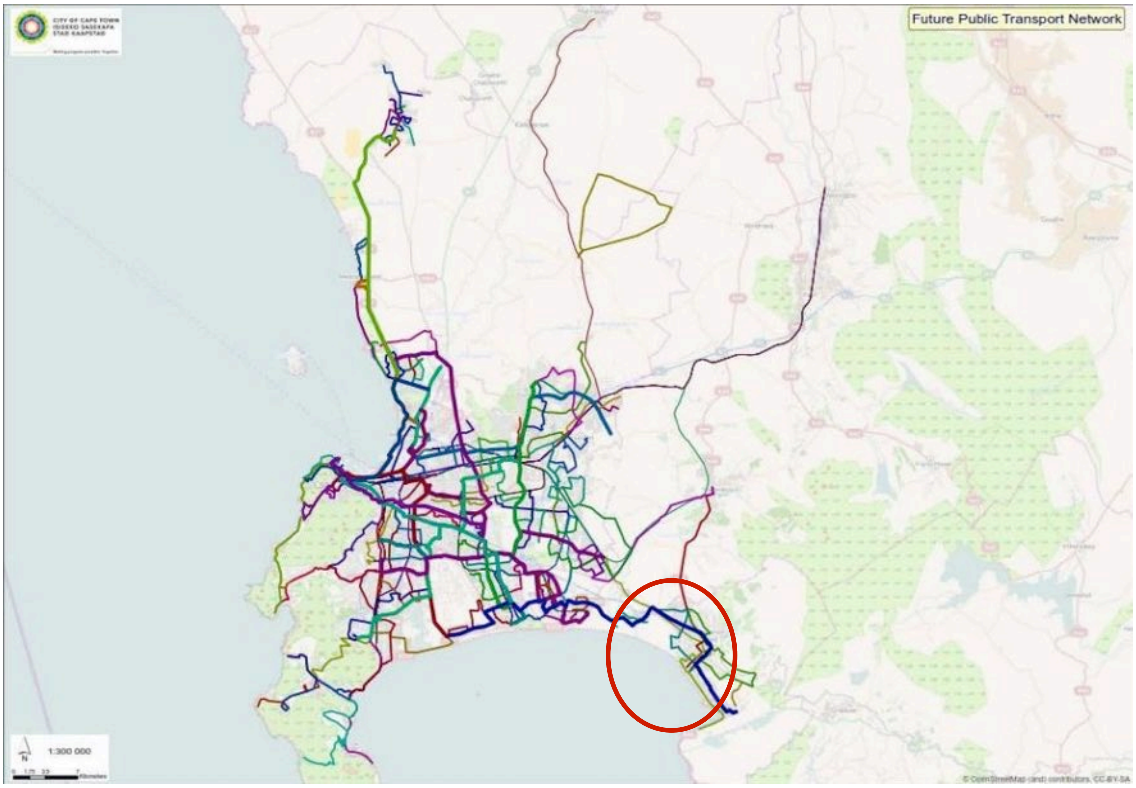
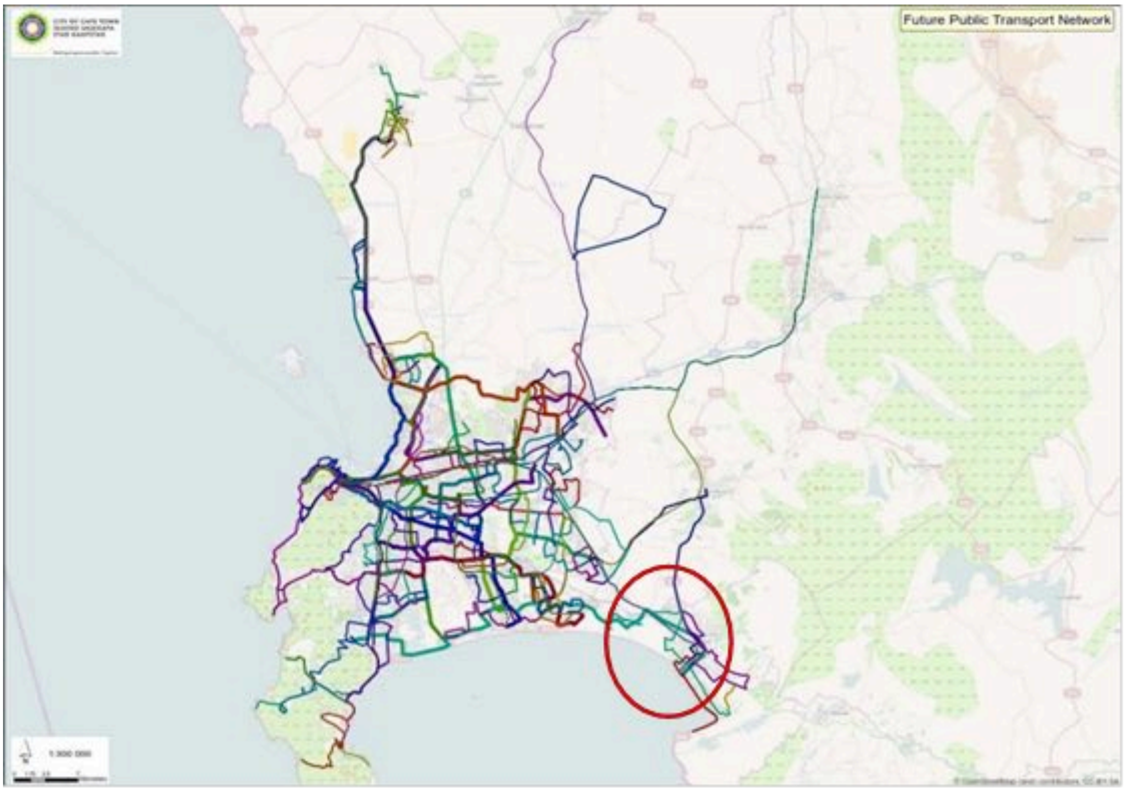


Figure 9-11: TA 5



When comparing the above five figures, the network progression from TA1 to TA2 and to TA3 is apparent. TA3 provides a strengthening towards the Strand/Gordon's Bay area (see the red circle in Figures 9-8 to 9-10. The network coverage between TA3, TA4 and TA5 is similar. The major difference being the replacement, in TA4 of some 80% of the scheduled feeder network service with unscheduled minibus taxis. In the TA5 scenario, the peak supply of vehicles has been limited in order to spread the high demand. The discussion regarding the increased intermodal linkages is based on the assumption that these facilities will be constructed at transfer locations in the expanding transport networks.

Table 9-22: Comparative Ranking - Linkages to intermodal transport facilities

Criteria	TA 1	TA 2	TA 3	TA 4	TA 5
Linkages to intermodal transport facilities.	0.1	0.15	0.25	0.25	0.25

This comparison rate TA 3, 4 and 5 the same, with TA 1 and 2 significantly lower.

9.4.3 *Linking residential areas and economic/industrial/commercial hubs*

In this regard, municipal residents need access to sufficient, evenly distributed economic and commercial opportunities by way of improved and integrated transport systems that will enhance city wide mobility and, if affordable, may introduce current excluded job seekers to other opportunities that were traditionally inaccessible due to access, distance and affordability constraints. Improved citywide linkages would also stimulate access to goods and services that may currently be inaccessible. The assessment here is related to the level of transport cover that the various TAs provide. The better and more extended the cover, the higher the rating.

Figure 9-12 to Figure 9-16 indicates a comparison of the trunk lines, the feeder network for the respective TAs.

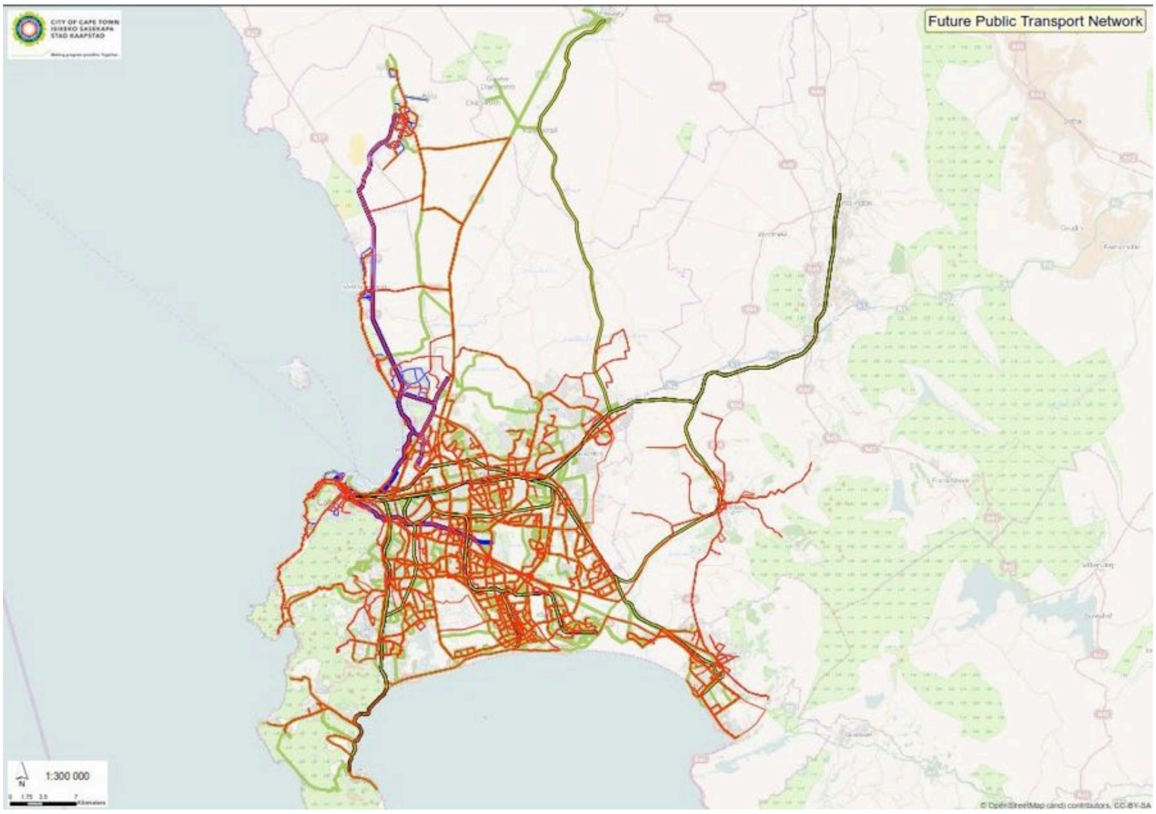


Figure 9-12: TA 1 – All modes combined.

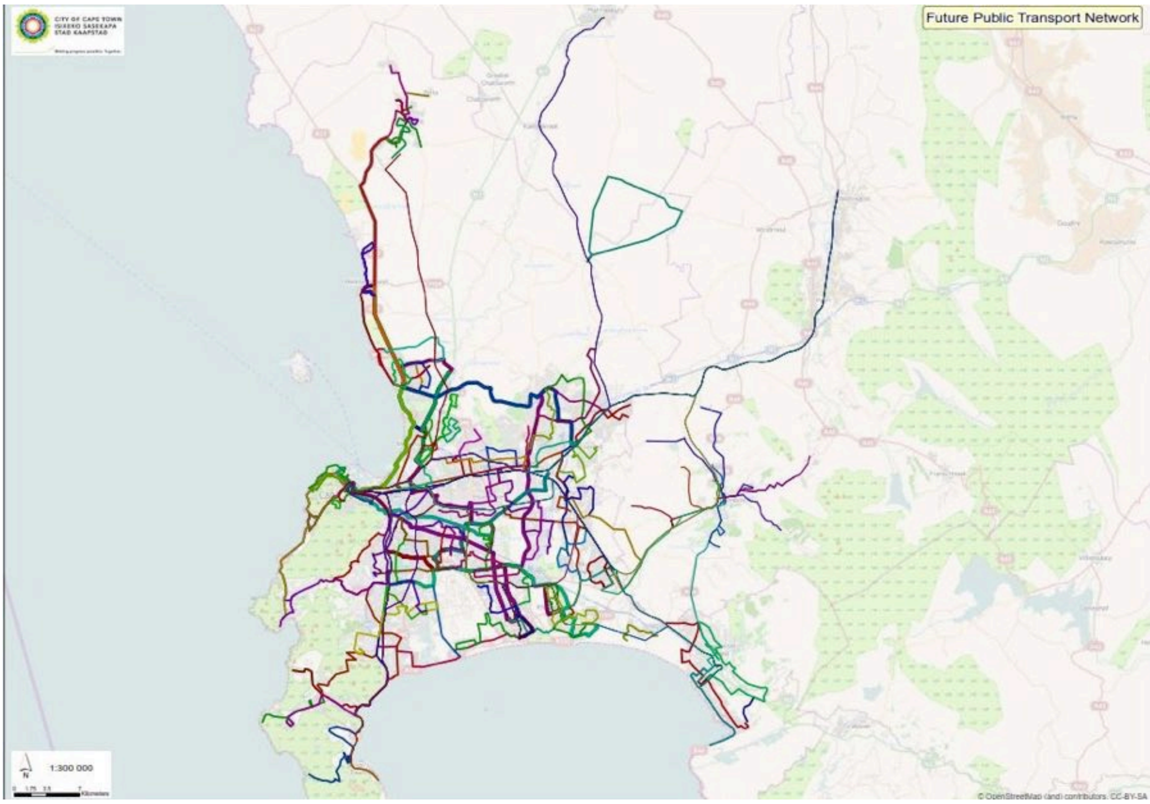


Figure 9-13: TA 2 – All modes combined

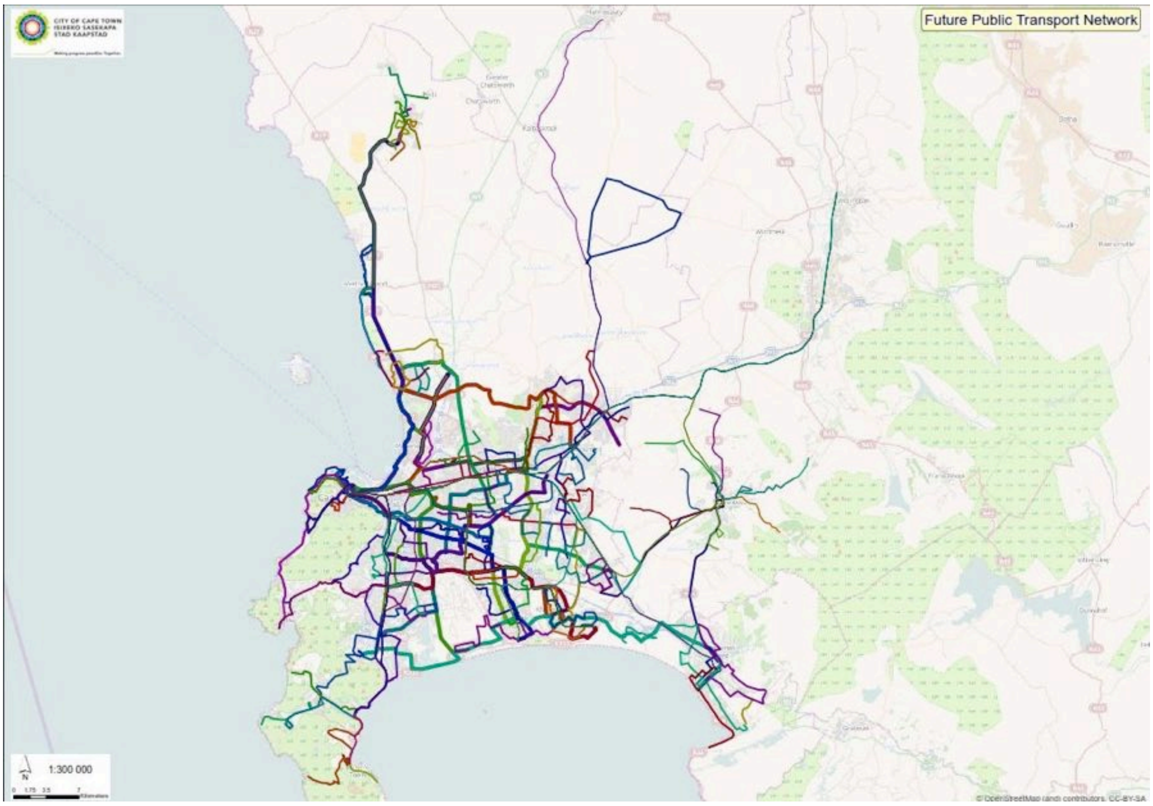


Figure 9-14: TA 3 – All modes combined

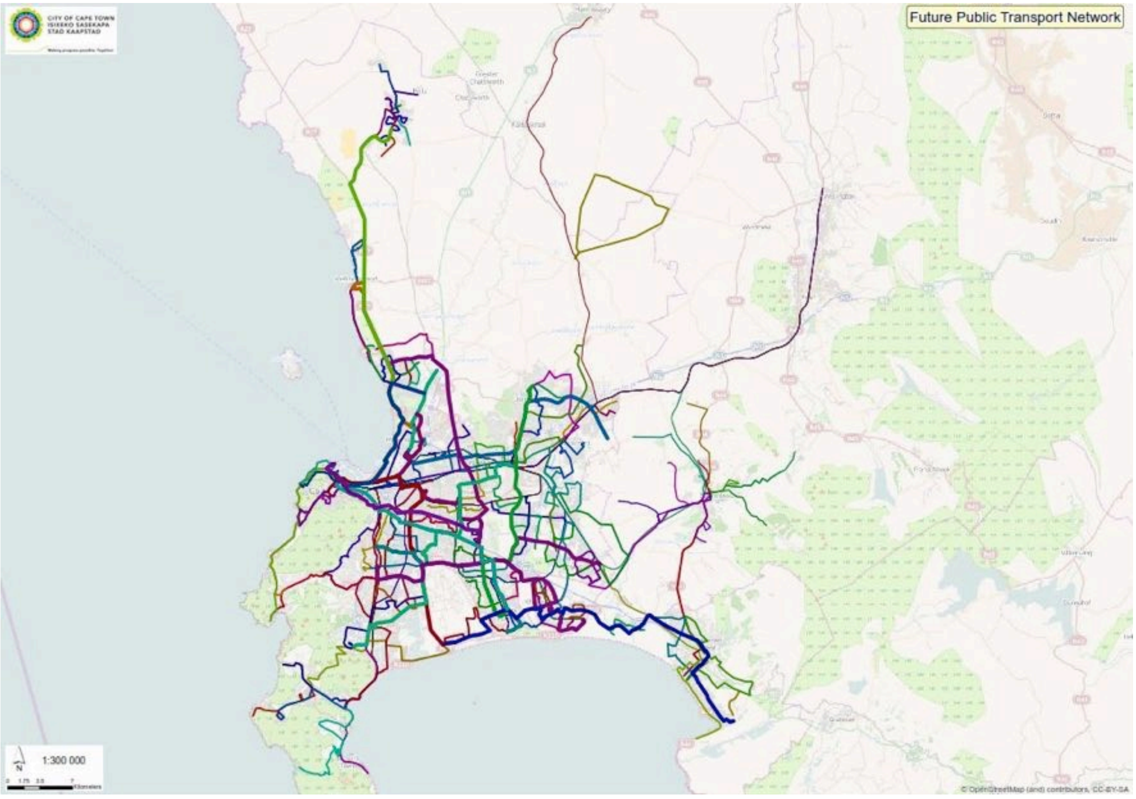


Figure 9-15: TA 4 – All modes combined

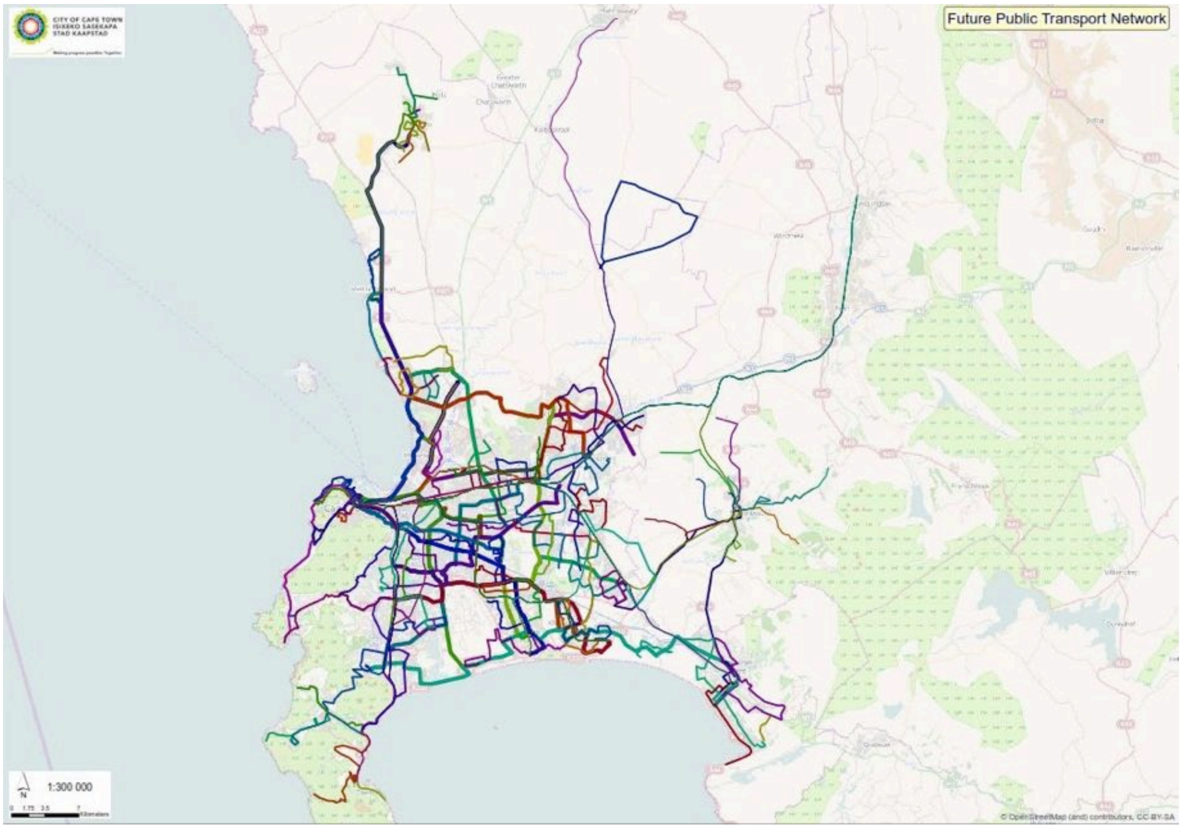


Figure 9-16: TA 5 All modes combined

When comparing Figure 9-12 to Figure 9-16, it is clear that the network cover changes from TA 1 and TA 2 (in particular) to TA 3 are apparent. The nature of the cover is, however, different. In TA 1 there is a comprehensive bus and taxi coverage, with limited IRT integration and coverage. TA 2 replaces the bus coverage with an extended IRT network with associated feeder routes. In essence, the nature of the transport cover shows differences. TA 3. 4 and 5 provides a further extension of the IRT and feeder route components and a closer integration with the extended rail network. However, though the nature of the coverage is different, TA 3, 4 and 5 provide extended citywide integration. From a social perspective, this is deemed more sustainable and opens up a variety of potentially positive impacts, if the assumptions indicated in the Background Section holds true.

Please refer to Table 9-23 for the comparative ranking.

Table 9-23: Comparative Ranking - Linking residential areas and economic/ industrial/ commercial hubs.

Criteria	TA 1	TA 2	TA 3	TA 4	TA 5
Linking residential areas and economic/industrial/commercial hubs.	**0.1**	**0.15**	**0.25**	**0.25**	**0.25**

This comparison rate TA 3, 4 and 5 the same, with TA 1 and 2 significantly lower.

9.4.4 ***Linking residential areas to social services and facilities, including health, education, security and leisure***

The comparative ranking, motivation and conclusions for this criterion are the same as for the criteria "Linking residential areas and economic/industrial/commercial hubs."

Please refer to Table 9-24 for the comparative ranking.

Table 9-24: Comparative Ranking - Linking residential areas to social services and facilities, including health, education, security and leisure.

Criteria	TA 1	TA 2	TA 3	TA 4	TA 5
Linking residential areas to social services and facilities, including health, education, security and leisure.	**0.1**	**0.15**	**0.25**	**0.25**	**0.25**

This comparison rate TA 3, 4 and 5 the same, with TA 1 and 2 significantly lower.

9.4.5 *Jobs Created*

This criterion would, in the case of a social impact assessment, typically focus on construction or project related job creation and related downstream opportunities. Ideally, there would be a substantial level of consultative information available to determine social feasibility of the different scenarios.

There is no doubt that improved access is one of the core criteria for socioeconomic growth and benefit. Improved access on a city wide level will inevitably result in a large number of positive social impacts. This is not, however, the focus of this report. In providing a comparison from a job creation perspective (it could also be seen as a poverty alleviation perspective), the focus must be on the different impacts that may result from TA 1 to 5. This enforces a limited viewpoint. From this perspective, the transportation related impacts for TA 3 to 5 is similar.

What is different is that, in the case of TA 4, some 80% of the scheduled feeder services are replaced with unscheduled private sector minibus type services. This issue could elevate the ranking of TA 4 above that of TA 3, based on the assumed job creation and related benefits from the addition of a significant unscheduled minibus type feeder service. It is risky to elevate a single factor such as this, but in the sense of the high level assessment, it is a contributing factor to be considered from a social perspective. In the case of TA 5, the key difference lies in the rescheduling of the peak to provide a broader utilisation band. For the purposes of this criterion, it does not provide any direct social benefit over TA 3 or 4.

Please refer to Table 9-25 for the comparative ranking.

Table 9-25: Jobs Created

Criteria	TA 1	TA 2	TA 3	TA 4	TA 5
Jobs created	0.1	0.2	0.2	0.3	0.2

This comparison rates TA 4 the highest, with TA 3, and 5 the same, although TA 1 and 2 rates lower.

9.4.6 *Conclusion*

In conclusion, TA 3, 4 and 5 holds clear benefits from a social perspective. TA 1 and 2 is limited in scope and does not provide an integrated citywide access, thus minimising the potential for a variety of social benefits to realise.

When considering the job creation perspective, TA 4 rates slightly better. It must be pointed out that this assessment is dependent on a number of assumptions. In conclusion, it becomes clear that the social perspective will in all probability not be the dominant factor in identifying the preferred alternative.

9.5 Alignment with Corporate Plans

In order to assess which of the five IPTN alternatives best fulfils the vision and goals of the City's corporate plans, the following three transport-related criteria have been extracted from the IDP for the assessment. These criteria are also reflected in the ITP vision.

- Attraction of investment to the City
- Improvement of safety in communities
- Increase in access to economic opportunities

9.5.1 *Attraction of investment*

The transport factors that are most likely to increase the confidence of investors to financially support development in the City are the amount of government spending on improving transport infrastructure and the quality of public transport service that is provided in the City.

The capital expenditure on transport infrastructure and vehicle fleets for each alternative is already included in one of the criteria under the economic assessment, so it has not been used again to reflect the attraction of investment. Instead, the quality of public transport has been measured for this assessment by the number of vehicle kilometres of scheduled service provided in each alternative with universally accessible vehicles. By 2032 it is assumed that PRASA's rail modernisation will have been completed and all stations and trains will be universally accessible. Minibus taxis, which are unscheduled and not universally accessible and the current contracted bus services which are also not universally accessible, will not increase the quality of public transport if they continue to operate as at present. The vehicle km of scheduled, universally accessible service obtained from the 2032 peak hour travel demand model is shown in Table 9-26.

Table 9-26: Vehicle km of scheduled, universally accessible service (2032 peak hour)

	TA1	TA2	TA3	TA4	TA5
Rail	15 794	20 103	16 507	16 345	16 345
BRT	1 751	27 766	52 797	43 309	52 554
Feeder	1 648	18 221	14 961	4 150	11 520
Total veh km	19 193	66 090	84 265	63 804	80 419
Rating	**0.23**	**0.78**	**1.00**	**0.76**	**0.95**

9.5.2 *Improvement of Safety in Communities*

The assessment of the alternatives with regard to accident potential is covered by the benefit/cost analysis under the economic assessment. The improvement of safety in communities with regard to increased security and prevention of crime is assumed to be related to the presence of frequent bus services for 18 hours per day on routes that are well lit and monitored via CCTV cameras. The length of trunk and feeder routes served by scheduled services in each alternative has therefore been used as a measure for the improvement of community safety in this assessment. The results are shown in Table 9-27 for each alternative, extracted from the 2032 travel demand model, excluding overlaps.

Table 9-27: Route length (km) of BRT trunks and feeders (2032)

	TA1	**TA2**	**TA3**	**TA4**	**TA5**
BRT trunks	65	249	407	405	407
Feeders	180	995	971	181	633
Total length	245	1244	1378	586	1040
Rating	**0.18**	**0.90**	**1.00**	**0.43**	**0.75**

9.5.3 *Access to Economic Opportunities*

The extent of access to economic opportunities provided by each of the IPTN alternatives has been assessed by measuring the amount of commercial floor space (GLA) within 500m radius of all the rail stations and bus stops on scheduled routes in each alternative. The GLA distribution is based on the pragmatic TOD land use scenario and includes the projected gross floor areas for all employment and retail activities throughout the Cape Town metropolitan region in 2032. The results of this analysis are shown in Table 9-28.

Table 9-28: Gross Floor Area (ha) within 500m of Rail Stations and Bus Stops (2032)

	TA1	**TA2**	**TA3**	**TA4**	**TA5**
Rail stations	139.65	162.70	145.52	145.52	145.52
Bus stops	875.09	920.01	977.96	510.98	831.22
Total GLA	1014.74	1082.71	1123.48	656.50	976.74
Rating	**0.90**	**0.96**	**1.00**	**0.58**	**0.87**

9.6 Strategic Economic Assessment

9.6.1 Introduction

An economic assessment was conducted to determine which of the future alternative network scenarios will be the most economically feasible. The results from the transport demand model were used to determine the cost and benefits for this analysis.

This report is comprised of the methodology of conducting the economic assessment, specifies the assumptions made and states the overall results which indicate the most preferred alternative according to economic feasibility. A sensitivity analysis was also conducted to calculate the effect of different scenarios influencing the costs and benefits of different alternatives. A wider economic benefit analysis was also conducted to indicate the multiplier effect of infrastructure investments for each Transport Alternative.

9.6.2 Methodology

This analysis used the outputs of the transport demand model and cost model to estimate the costs and benefits for five different alternatives. The capital and maintenance infrastructure costs for each alternative were calculated and the following direct benefits were included in this estimation:

i) Travel time savings
ii) Road User Cost savings
iii) Accident cost savings

The Guidelines for Conducting ECONOMIC EVALUATION OF URBAN TRANSPORT PROJECTS 3rd Edition May 2001, was used as the framework to conduct this economic assessment. The following (see Figure 9-17) economic evaluation process for transport improvement projects was used.

All costs are expressed in 2013 terms. Economic costs for all input values were used by applying a shadow price factor (SPF) to all cost.

For this analysis a social discount rate of 8% per annum is proposed for the 20 year analysis period.

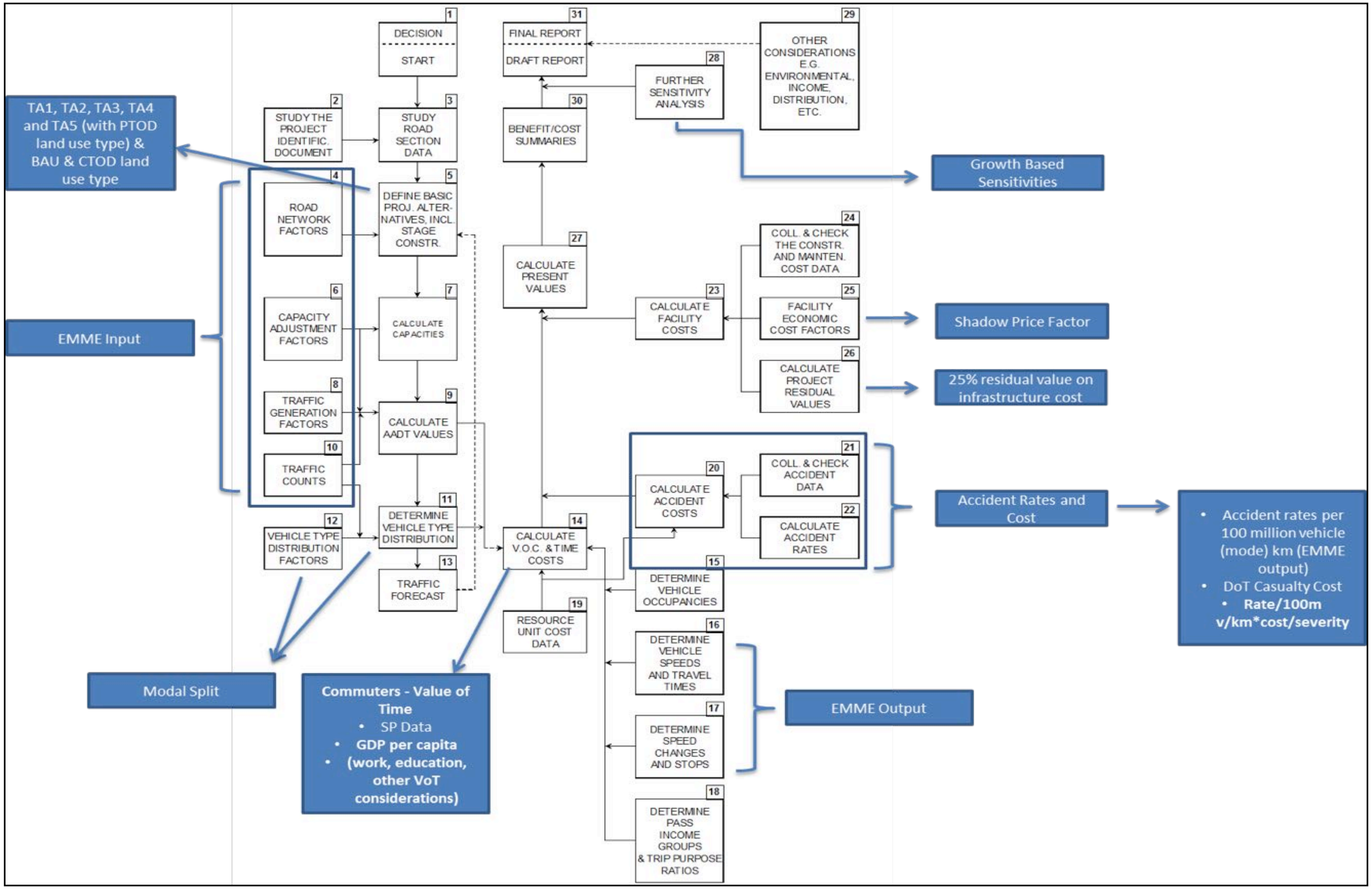


Figure 9-17: Economic Evaluation Process

Project Alternatives
Five alternatives were modelled in the CoCT Transport Demand Model and used in this economic analysis. All alternatives (TA2 – TA5) were compared to the base alternative (TA1) which is considered the "do minimum" in terms of investing in public transport infrastructure in the next 20 years. These Transport Alternatives were discussed in detail in Chapter 5 of this report and are summarised as follows:

- Transport Alternative One (TA1) – "Do Minimum",
- Transport Alternative Two (TA2) – "Rail Dominant with limited BRT",
- Transport Alternative Three (TA3) – "Limited Rail and more BRTs"
- Transport Alternative Four (TA4) – "1st refined Alternative"
    - Financial affordability – Replace 80% of feeders with minibus taxi's
- Transport Alternative Five (TA5) – "2nd refined Alternative"
    - Financial affordability – Reduce peak Level of Service (limit headway) and re-place 20% of feeders with minibus taxis

9.6.3 *Assumptions*

Daily traffic distribution
. The demand model only estimates the AM peak hour traffic and expansion factors were used to expand the AM peak hour savings (in time and user costs) to daily and ultimately annual savings. It was assumed that there will be 100% savings during the peak hours, with different assumptions for the off-peak and weekend savings.

The following expansion factors were used (Table 9-29).

Table 9-29: Expansion Factors

Benefit	Expansion factor: PH-Day	Expansion factor: Day-Year
Travel Time[17]	3	249
RUC (private vehicles)	6.77	301

Vehicle occupancy
An average vehicle occupancy of 1.2 occupants per private vehicle was assumed. This was used to calculate the travel time savings per vehicle.

[17] The travel time savings for the peak hour was only assumed for the peak period (AM and PM peak).

Trip purpose
Three different trip purposes were modelled and the percentage of commuters for each of the trips purposes was calculated.

Trip Purpose:

- Home based Work (HBW),
- Home based Education (HBE) and
- Home based Other (HBO)

Commuters have different values of time for the different trip purposes and modes. The value of time was calculated using the results from the 2013 stated preference survey conducted in the City as part of the household travel survey. The value of time for each mode and trip purpose is shown in Table 9-30 below:

Table 9-30: Value of time for each trip purpose

Trip purpose	Value of time (R per hour)				
	Private Vehicle	**Rail**	**Contracted Bus**	**MyCiTi BRT**	**MyCiTi Feeder**
HBW	35	8	13	17	15
HBE	35	8	13	17	15
HBO[18]	8	2	3	4	3

9.6.4 *Cost*

The direct cost taken into account in this analysis is the capital infrastructure cost (considered to be invested in Year 1) and the routine maintenance cost on public transport routes (road and rail) over the next 20 years.

Transport infrastructure investment cost & maintenance
Infrastructure unit costs and maintenance cost were received from the City of Cape Town. No unit cost information was received from PRASA on infrastructure investment cost or maintenance cost for rail. The latest available rail cost figures from 2009 were escalated to 2013 in real terms and were used for calculating the rail expenditure over the 20 year period. The Fisantekraal Rail Feasibility study (2013) was used for the capital expenditure on the Fisantekraal and Atlantis Rail lines.

Table 9-31 to Table 9-36 indicates the unit cost for Rail and MyCiTi services.

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[18] Assume only 23% from the savings of HBW and HBE. This percentage was derived from a Value of Time study by Conningarth Economist "A Manual for Cost Benefit Analysis in South Africa with Specific Reference to Water Resource Development".

Rail

Table 9-31: Rail improvement cost

Rail improvement	Rate per km – R' 000: All Cost (including VAT)	Rate per km (single line) – R' 000: Excl Stations and Bridges (including VAT)	Station (R per station) – R' 000 (including VAT)	Bridge cost (R/m^2) (including VAT)
Fisantekraal	R30 000			
Atlantis		R30 000	R20 000	R20 000
Blue downs		R50 000	R20 000	R20 000
Chris Hani Rail extension		R50 000	R20 000	R20 000

Table 9-32: Rail Maintenance and Depot Cost

Rail Maintenance & Depot	Rate per km – R' 000 (including VAT)	Station (R per station) – R' 000 (including VAT)	Depot (R per vehicle) – R' 000 (including VAT)
Route maintenance (Rail track)	R255		
Station Maintenance		R5 000	
Depot (Infrastructure cost)			R1 500

MyCiTi Trunk

Table 9-33: MyCiTi Trunk improvements cost

MyCiTi Trunk improvements	Rate per km – R' 000 (including VAT)	Bridge cost (R'000/m^2) (including VAT)	Depot / Staging (R'000/vehicle)
Route infrastructure (including Bus lanes, stations-single platform/stops, expropriation)	R53 000		
Route infrastructure (including Bus lanes, stations (double platform)/stops, expropriation)	R58 000		
Bridge Cost		R20 000	
Depot Cost			R400
Staging Cost			R200

Table 9-34: MyCiTi Trunk Maintenance cost

MyCiTi Trunk Maintenance	Rate per km – R' 000 (including VAT)
Route maintenance	R145

(Busway & stations-single platform)	
Route maintenance (Busway & stations-double platform)	R160

MyCiTi Feeder

Table 9-35: MyCiTi Feeder improvement cost

MyCiTi Feeder improvements	**Rate per km – R' 000 (including VAT)**	**Depot / Staging (R'000/vehicle)**
Route infrastructure (including stops)	R2 500	
Depot Cost		R400
Staging Cost		R200

Table 9-36: MyCiTi Feeder Maintenance cost

• **MyCiTi Feeder Maintenance**	• **Rate per km – R' 000 (including VAT)**
• Route maintenance	• R6.25

The additional infrastructure for each mode (line km) and economic infrastructure cost for all alternatives is shown in Table 9-37 (compared to the Base Alternative TA1).

Table 9-37: Economic Infrastructure Cost

Infrastructure Cost (R '000 000)		**TA2**	**TA3**	**TA4**	**TA5**
Rail	**Additional line km**	81	37	20	37
	Econ Infrastructure Cost	R2 751	1 328	910	1 328
BRT Trunk	**Additional line km**	184	342	340	342
	Econ Infrastructure Cost	R9 157	R16 185	R15 090	R16 185
BRT Feeder	**Additional line km**	815	790	1	790
	Econ Infrastructure Cost	R1 519	R1 473	R2	R1 473
Total Infrastructure Economic		R13 428	R18 987	R 16 002	R18 987

cost				

9.6.5 *Economic Benefits*

The upgrading and extension of existing public transport services can have a considerable economic benefit to commuters travelling for various activities. Current public and private transport users can benefit from the new service due to the reduction in travel time, reduced vehicle user cost and reduction in accident rates. Other transport users, such as non-motorised transport users, may also benefit in using the new improved public transport system. The new system can also be favourable to people not currently using existing modes due to higher accessibility and better mobility provided by the new public transport system.

The direct benefits derived from the new public transport system can result from the reduction of travel time; the reduction in vehicle kilometres travelled and reduced accident cost. These benefits are described as follows:

Direct benefits
1. Reduction in travel time
Individuals place a value on the time they spend travelling. This travel time cost can be influenced by many factors such as the trip purpose, the expected duration of the trip, the personal comfort during a journey and the chance of delay due to traffic. The trip purpose is usually the main determinant of the value of travel time and commuting trips are higher valued than non-commuting trip (such as visiting the shops or for other recreation).

When introducing a new transport system such as BRT commuters may change their mode of transport. Current bus users will use the new improved system which will result in a reduction of travel time. Private transport can also become less congested and result in reduced travel time.

2. Reduction in road user cost
The total vehicle kilometres travelled can be reduced due to the transport investment made on a new public transport system. A proportion of the private vehicle users will switch to public transport which will reduce the total vehicle kilometres travelled for private vehicles, but increase the user cost for public transport. The reduction of cost includes the direct marginal monetary cost, such as, fuel cost, deterioration, wear and tear etc.

Indirect benefits
3. Reduction in accident cost

The number of accidents is usually correlated with the total vehicle kilometres travelled. The higher the vehicle kilometres travelled the higher the amount of accidents. A new public transport system can have a significant effect on reducing the amount of accidents in a city and can be quite considerable if users switch from private vehicle usage.

Travel Time Savings
The passenger hours travelled in the AM peak hour was obtained from the EMME model for each mode and was expanded to a daily total. Table 9-38 below indicates the total

passenger hours travelled for each mode in the AM peak hour. Private vehicle travel contributes significantly more to the travel time than public transport.

Table 9-38: Total passenger hours of travel in the peak hour by mode

Total pass hours (Peak Hour)	TA1	TA2	TA3	TA4	TA5
Private Vehicle	2 375 594	2 198 308	1 833 766	2 022 722	1 833 766
Minibus Taxi	114 792	3 455	508	40 079	6 828
Contracted Bus	99 467				
Rail	157 850	165 243	127 086	123 149	127 086
MyCiTi	6 715	109 634	171 659	150 296	165 339

Table 9-39 below indicates the total passenger hours travelled by mode and the travel time cost for each alternative during the AM peak hour. Transport Alternatives TA2 to TA5 shows significant travel time savings compared to TA1.

Table 9-39: Travel Time Savings

Travel Time (TT)	TA1	TA2	TA3	TA4	TA5
Total pass hours (Peak Hour)	2 754 419	2 476 639	2 133 019	2 336 246	2 133 019
TT Annual Cost (R'000 000)	R 64 988	R 59 527	R 50 614	R 55 657	R 50 614
TT Annual Savings (R'000 000)	R	R 5 461	R 14 375	R 9 331	R 14 375

Road Use Cost Savings
The private vehicle road user cost was calculated by multiplying the total vehicle kilometres travelled in the AM peak hour with the average economic user cost per kilometre. This was expanded to get the total RUC annual savings per Alternative. Table 9-40 below indicates these savings. This table indicates major RUC savings for private vehicles.

Table 9-40: Private vehicle total vehicle kilometres and roads user cost savings

Road Use Cost - Private vehicle	TA1	TA2	TA3	TA4	TA5
Total veh km (PH)	7 996 602	7 232 494	6 204 671	6 512 423	6 204 671

RUC Cost (Year) R'000 000	R 17 727	R 16 033	R 13 755	R 14 437	R 13 755
RUC Annual Savings R'000 000		**R1 693**	**R 3 972**	**R 3 290**	**R 3 972**

The user cost savings were derived from the cost model estimations for the different public transport modes. A shadow price factor was applied to get the economic cost. This is shown in Table 9-41. The high RUC for TA1 is due to the high number of minibus taxi's required to supply the demand. A reduction in the minibus taxi cost was tested in a sensitivity analysis as shown at the end of this chapter.

Table 9-41: Public Transport Road User cost savings

Public Transport RUC Cost (Year)	**TA1**	**TA2**	**TA3**	**TA4**	**TA5**
Per annum (R'000 000)	R 42 172	R 24 091	R 22 188	R 20 900	R 16 472

Table 9-42: Average Accident Rates by mode

Average Accident Rates	**Private Vehicle**	**Rail**	**Contracted Bus**	**Minibus Taxi**	**MyCiTi**
Average No accidents per 100 million veh/km	130				
Average No accidents per 1 billion pass/km	-	13	920	2 608	11

A weighted average accident cost rate was used. These rates were derived from the Department of Transport and escalated to 2013 rates. This is shown in Table 9-43.

Table 9-43: Average Accident Cost

Average ACCIDENT COST	
Accident type	**R / incident**
Fatal	R 895 236
Serious	R 375 208
Slight	R 181 588
No injury/ Damage only	R 49 295

Weighted Average	R 77 321

Table 9-44 indicates the annual accident savings for all modes. The reason for the negative savings for MyCiTi and Rail is due to the higher number of passenger kilometres travelled on these modes compared to the base alternative (TA1).

Table 9-44: Accident savings by mode and Alternative

Accident Savings	TA2	TA3	TA4	TA5
Private Vehicle (R'000)	R 156 860	R 367 858	R 304 681	R 367 858
Minibus Taxi (R'000)	R 134 531	R 137 079	R 99 621	R 131 685
Contracted Bus (R'000)	R 257 535	R 257 535	R 257 535	R 257 535
MyCiTi (R'000)	R -73	R -113 389	R -78 169	R -88
Rail (R'000)	R -4 017	R -1 457	R -1 149	R -1 457
Total annual accident savings (R'000)	R 544 836	R 760 903	R 660 611	R 755 534

9.6.6 *Results*

Transport Alternatives TA2 to TA5 were compared relative to the Base Alternative TA1. A discounting rate of 8% was used to discount the cost and benefits considered for the life cycle of the project. An analysis period of 20 years was used.

The results show (see Table 9-45) that all alternatives are economically viable with all alternatives having an internal rate of return (IRR) higher than 8%. The B/C ratio is also above 1 for all alternatives, indicating that each alternative is economically feasible.

Table 9-45: Economic Analysis Results

Economic Indicators	TA2	TA3	TA4	TA5

IRR	191%	205%	215%	236%
NPV (R'000 000)	R 216 069	R 329 342	R 291 787	R 380 412
B/C ratio	17	19	20	22

The results show an extremely high IRR for all alternatives with the highest IRR for Alternative 5. This is due to the major increase in public transport usage and the reduction in private transport usage compared to TA1 which impacts on the travel time savings and RUC savings over a 20 year period. This overshadows the relatively small infrastructure investment for the alternatives. It should be taken into consideration that these are economic savings for the City as a whole and does not result directly in financial savings.

Alternative TA5 is the most economically viable and the preferred alternative from a transport economic perspective. The result is as expected considering the decrease in RUC savings due to the peak supply capping which reduces the vehicle kilometres travelled significantly.

It should however be noted that all the Transport Alternatives are only viable from a transport economic perspective and other external considerations could impact on this analysis. Most of these other considerations were taken into account in the other assessments (social, alignment with corporate plans, transport and environmental) which could impact on the feasibility of these alternatives. This is taken into account in the Multi Criteria Analysis discussed in Chapter 10 of this report.

It should also be taken into account that these savings could potentially increase should the City implement policies with regard to land use densification. The economic analysis shows that major savings could accrue due to travel time savings and reduced vehicle kilometres travelled compared to the total infrastructure investment over 20 years. This can be achieved by ensuring land use to develop along transport corridors according to a more Comprehensive TOD land use scenario.

The results also indicate that TA3 (which includes a greater length of dedicated trunk routes) is more economically viable than TA2. This shows that the benefits resulting from investing in dedicated trunk infrastructure (Rail and BRT) will compensate for the higher investment cost due to the higher shift in commuters from private vehicles to public transport.

9.6.7 Sensitivity analysis

A sensitivity analysis was conducted to evaluate the effect of certain changes in the cost and attributes used to calculate the economic feasibility as discussed in the sections above.

The following scenarios were tested:

1. Only include the benefits of travel time savings for public transport (Exclude the time savings for private transport)
2. Only include the benefits of road user cost savings for public transport (Exclude the road user cost savings for private transport)
3. Reduce Public Transport road user cost for TA1 by 50%

4. Increase the infrastructure cost by 50%

Table 9-46 indicates the result of this sensitivity analysis.

Table 9-46: Sensitivity Testing - Benefit / Cost Ratio

B/C ratio - Sensitivity testing	TA2	TA3	TA4	TA5
Base	17	19	20	22
1. Travel Time savings for Public Transport Only	14	12	15	15
2. RUC savings for Public Transport Only	16	17	18	20
3. Reduce Public Transport RUC for TA1 with 50%	3	9	8	12
4. Increase Infrastructure cost with 50%	12	13	13	15

The sensitivity analysis results indicate that all alternatives will still be economically viable for the different scenarios.

Scenarios 1 and 2 in the above table (exclude savings for private vehicles) were tested due to the extreme savings in private vehicle travel time and RUC resulting from high congestion in 2032. The results show that the Transport Alternatives will remain feasible even by only including the benefits for public transport users.

Scenario 3 (reduce the RUC for TA1 by 50%) resulted in the largest change in B/C ratio. This scenario was tested due to the high road user cost of the minibus taxis in TA1. It is possible that the real cost for operating a minibus taxi service could be lower than stated in this project's cost estimations as it is extremely difficult to quantify this cost. However, the economic feasibility indicates that all Transport Alternatives remain feasible even though the RUC of TA1 is reduced by 50%.

The sensitivity analysis indicates that although the infrastructure investment cost increases by 50%, all scenarios will still have a B/C ratio of more than 1.

9.6.8 *Wider Economic Benefits*

The benefit / cost analysis conducted in section 9.6.6 does not take into account the wider economic benefits and only considers the direct benefits that result from infrastructure expenditure.

It is also important to take into account the wider and indirect economic benefit of investing in transport infrastructure. These wider economic benefits are however very difficult to quantify and require extensive research to determine the different effects on the economy for capital expenditure in certain industries within a country. Most of these wider economic benefits were taken into account in the other assessments in this chapter, so this section considers the welfare effect of transport infrastructure investment.

IA simplified analysis was conducted to assess the potential multiplier effect for each of the investment options discussed under section 9.6.4 and a sensitivity testwas done to indicate the effect on the B/C ratio for different multipliers to account for certain "leakages" in the system.

A thorough economic welfare impact analysis involves extensive research and economic impact modelling using "Input-Output" techniques, which is out of the scope of this study. A very high-level approach was therefore followed to get a rough indication of the potential wider economic impacts of the different Transport Alternatives by applying economic impact multipliers to the total capital costs.

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In a study by Ngandu, Garcia and Arndt, 2010: The Economic Influence of Infrastructural Expenditure in South Africa: A Multiplier and Structural Path Analysis, it explains the structural flow of investment into different sectors when investing in infrastructure. The areas in which infrastructure investment could affect growth are factors of production, compliments of production, stimulus of capital and labour factors as well as the distribution in income for institutions (households and enterprises). It is however important to take into account the flows to exogenous accounts which are "leakages" from the system. Such financial outflows in the case of production are to imports and taxes and should be excluded from the wider economic analysis. Also, the investment in transport infrastructure includes the increased use of factors in production (labour and capital). It is thus assumed in this analysis that these resources are unemployed which is a reality in South Africa for the unskilled workforce, but not necessarily for skilled labour. This investment in production should however take the "leakages" of income tax and savings into account. All these factors mentioned above could impact the wider economic evaluation by overestimating the wider economic benefits for this project.

This wider economic analysis is based on a recent study conducted by Burrows and Botha (2013) to explain the changing input-output multipliers in South Africafrom 1980 to 2010. This study indicates the changes in GDP multipliers over this 30 year period for 46 industries in South Africa. The total GDP multiplier is used for this study which includes the direct, indirect and induced effect on the economy if an additional unit of output is produced. This is considered as one of the most important types of GDP multipliers calculated (Burrows, Botha, 2013).

This study also shows the ranking of each of the 46 industries by comparing their multiplier effect. It indicates that the Civil Engineering construction industry is ranked fairly low in terms of this industry's multiplier effect compared to the other 45 industries (27th out of 46 in 2010).

This study indicated a 1.5174 multiplier for the Civil Engineering construction industry which has been used for this wider economic analysis of IPTN alternatives. This is a generic multiplier and may overestimate the benefits for this project. To account for possible financial outflow and leakages, a sensitivity test was conducted where the multiplier was reduced by certain percentages to look at the effect on the overall welfare should there be different leakages out of the system.

Table 9-47 below indicates the total investment in infrastructure, vehicle capital cost and rolling stock for each transport alternative and also indicates the potential wider economic benefits that may occur taking into account the generic multiplier of 1.5174

Table 9-47: Wider Economic Benefits - Multiplier effect

Wider Econ Benefits	**TA 1 - Do minimum**	**TA 2 - Rail Biased**	**TA 3 - IRT Biased**	**TA 4 - Financial Biased**	**TA 5 - Reduced LOS**
ITEM	**(R - ,000 000)**	**(R - ,000 000)**	**(R - ,000 000)**	**(R - ,000 000)**	**(R - ,000 000)**
Equipment Economic costs	R 8 584	R 8 431	R 7 729	R 7 597	R 5 607
(Add) Infrastructure Economic costs	R 0	R 13 428	R 18 987	R 16 003	R 18 987
Total Economic costs	R 8 584	R 21 860	R 26 716	R 23 600	R 24 594
Multiplier	1.5174	1.5174	1.5174	1.5174	1.5174
Total Welfare	**R 13 025**	**R 33 170**	**R 40 538**	**R 35 811**	**R 37 319**

The results indicate the potential welfare effect of investing in transport infrastructure and vehicle equipment for this project which could increase the economic feasibility of such a project.

In view of the high-level approach and uncertainty regarding the assumptions made a sensitivity test was conducted to analyse the effect on the feasibility of such a project by decreasing the multiplier used in the analysis above to account for possible financial outflows ("leakages") in the system. The results are shown in Table 9-48 below.

Table 9-48: Wider Economic Benefits - Welfare effect for a reduction in the multiplier

Total Welfare Effect (Rand)	TA 1 - Do minimum	TA 2 - Rail Bias	TA 3 - IRT Bias	TA 4 - Financial Bias	TA 5 - Reduced LOS
% decrease in Multiplier effect	**(R - ,000 000)**	**(R - ,000 000)**	**(R - ,000 000)**	**(R - ,000 000)**	(R - ,000 000)
20%	**R 10 420**	**R 26 536**	**R 32 431**	**R 28 649**	**R 29 855**
40%	**R 7 815**	**R 19 902**	**R 24 323**	**R 21 487**	**R 22 391**
60%	**R 5 210**	**R 13 268**	**R 16 215**	**R 14 324**	**R 14 927**

10. Selection of preferred IPTN

10.1 Introduction

Based on the assessments conducted in Chapter 8 and 9 a Multi Criteria Analysis (MCA) was conducted to determine the most sustainable IPTN Alternative as the preferred network to be rolled out over the next 20 years. The sections below explain the process for determining the assessment criteria as well as conducting the MCA.

10.2 Selection of criteria

The specialists responsible for the assessments explained in Chapter 9 presented the CoCT Project Management Team with the methodology and proposed assessment criteria to be tested under each evaluation. These criteria were refined through workshops with the CoCT Project Management team which resulted in selecting the most important and relevant assessment criteria to be included in the MCA.

The criteria shown in Tables 10-1 to 10-6 were agreed on by the Project Management Team for the MCA:

Table 10-1: Environmental Assessment Criteria

Criteria Name	Criteria Detail	Reasoning for measuring this item	What is this item comprised of (i.e. input)	Assumptions	What is the output
Loss of sensitive habitat	Extent of spatial conflict between sensitive ecology and new infrastructure	Spatial extent of land take that affects sensitive habitat as identified in the BioNet. Losses of habitat should be avoided at all costs.	Spatial extent (ha) vs. spatial extent (ha)	Rail expansion is limited to the Blue Downs Corridor, and a 100m buffer applied to each side of the centreline All trunk routes are assigned a 40m average servitude All feeder routes are assigned a 20m average servitude	Hectares (of habitat lost)
Total air pollution	Total emissions of PM and NOx	Two of the primary air pollutants are particulate matter and oxides of nitrogen and the ideal is to limit the total contribution to ambient pollution levels	emissions factors x km travelled	Best available emissions factors; Presumptions regarding future emissions factors; Calculations only done on AM peak hour to limit uncertainty and since only a comparative rating is required	g or kg (of a pollutant)
Exposure to air pollution	Size of population affected by pollution along main transport routes	The direct exposure of people to concentrated pollutants from vehicles must be limited, and therefore the alternative with the lowest number of people exposed to combustion emissions is preferred.	no. of people within 200m corridor x emission factor x total km travelled for each mode	Future population densities; emissions calculations for Total Air Pollution	g or kg (of pollutant) per person
Greenhouse gas emission	Total greenhouse gas emissions from all modes	The lower the overall contribution to GHG concentrations, the more preferred the alternative.	total km travelled x emission factor	Best available emissions factors; Presumptions regarding future emissions factors; Calculations only done on AM peak hour to limit uncertainty and since only a comparative rating is required	ton CO_2eq

Energy consumption	Total energy consumed for all modes	The lower the overall energy usage, the more preferred the alternative.	total km travelled x energy consumption factor	Best available consumption factors; Presumptions regarding future consumption factors; Calculations only done on AM peak hour to limit uncertainty and since only a comparative rating is required; Emissions factors from ESKOM for 2013;	GJ

Table 10-2: Transport Assessment Criteria

Criteria Name	Criteria Detail	Reasoning for measuring this item	What is this item comprised of (i.e. input)	Assumptions	What is the output
Modal split (public transport users vs total transport users)	Total trips on public transport and NMT, versus total number of trips being undertaken	The objective of the City is to maximise the public transport modal split to relieve congestion and to increase public transport ridership to increase the financial viability of the system (operational cost coverage).	Output from EMME model	Exclude all intra zonal trips. All trip purposes. AM peak hour	Total number of trips on public, private and NMT.
Total vehicle-km per mode	Total vehicle-km of travel on each of the modes	Objective to minimise the total vehicle kilometres travelled per mode.	Output from EMME model	Exclude all intra zonal trips. All trip purposes. AM peak hour. All modes will be compared.	Total vehicle-km per mode
V/C ratio	Km of road with volume/capacity >1.0	Transport Alternative with a lower % of road with a volume/capacity ratio of >1.0 is preferred	Output from EMME model	N/A	The output will be km of road with v/c >1.0
Average travel time	Average travel time on different modes, road and rail	The CoCT ITP have the following objective: operating speed of between 30-50 km/h and that 80% of passengers should not travel more than 60 minutes	Output from EMME model	Use the travel time from each centroid connector of the TZ to another TZ. AM peak hour travel times. All modes	Average operating speed per mode will be used together with average trip length by mode to determine average travel time by mode.

Table 10-3: Social Assessment Criteria

Criteria Name	Criteria Detail	Reasoning for measuring this item	What is this item comprised of (i.e. input)	Assumptions	What is the output
Avoid resettlement.	Number of resettlements required.	Avoid resettlement as far as possible.	Input from spatial planning, network and transport planning processes.	Can become a fatal flaw.	Number of resettlements.
Minimise expropriation	Number and magnitude of expropriations required.	Minimise the negative social impacts of selected alignments.	Input from spatial planning and network design processes.	Expropriation has the potential to trigger social mobilisation against the project.	Comparative - least is better.
Jobs created	Number of jobs created.	Maximise local economic benefit.	Input from economic and network design processes.	Local job creation will be contractually enforced.	Number of jobs created - more is better.
Linkages to intermodal transport facilities.	Comparative number of linked intermodal transport facilities.	Supports the Urban Network Strategy by optimising access to social and economic opportunities for all and especially the poor. Enhanced social mobility and improved access may introduce currently excluded job seekers to other opportunities that were traditionally inaccessible due to access,	Input from spatial, network and transport planning processes.	Affordability will be maximised as far as possible.	Comparative number of linked intermodal transport facilities. More is

		distance and affordability constraints. It would also stimulate access to goods and services that may currently be inaccessible.	GIS spatial linked comparison.		better.
Linking residential areas and economic/industrial/commercial hubs.	Comparative number of linked hubs.	An integrated affordable, safe and reliable transportation system will enhance the Inclusive City approach. In this regard , municipal residents needs access to sufficient, evenly distributed economic and commercial opportunity by way of improved and seamless transport integration will enhance city wide mobility and, if affordable, may introduce current excluded job seekers to other opportunities that were traditionally inaccessible due to access, distance and affordability constraints.	Input from spatial, network and transport planning processes. GIS spatial linked comparison.	Affordability will be maximised as far as possible.	Comparative number of linked hubs and activity areas. More is better.
Linking residential areas to social services and facilities, including health, education, security and leisure.	Comparative number of linked facilities.	In this regard, municipal residents need access to sufficient, evenly distributed amenities by way of enhanced and seamless transport integration. This will enhance city wide mobility and, if affordable, may maximise public access to social, services and facilities.	Input from spatial, network and transport planning processes. GIS spatial linked comparison.	Affordability will be maximised as far as possible.	Comparative number of linked hubs and specific facilities. More is better.

Table 10-4: Alignment with corporate plans Assessment Criteria

Criteria Name	Criteria Detail	Reasoning for measuring this item	What is this item comprised of (i.e. input)	Assumptions	What is the output
Investment attraction	Attraction of investment to the City	One of the goals of the City's IDP	Capital cost of infrastructure	Jobs are related to cost of infrastructure	Construction cost of infrastructure
Safety in Communities	Increase safety of vulnerable communities	One of the goals of the City's IDP	Length of BRT routes in low income communities	Frequency of vehicles and lighting increase safety and security	Length of IRT and feeder routes in low income communities
Economic opportunity	Increase access to economic opportunity	One of the goals of the City's IDP	Number of employment opportunities within 500m of PT stop/station	PT enhances access to economic opportunity	%of employment within 500m of PT stops/stations

Table 10-5: Cost Assessment Criteria

Criteria Name	Criteria Detail	Reasoning for measuring this item	What is this item comprised of (i.e. input)	Assumptions	What is the output
Deficit / Surplus (Operations only)	Affordability of Operational cost of the IPTN system	Affordability of Operational cost of the IPTN system	Vehicle kilometres and passenger volumes are received from the EMME model. Unit cost estimates for all modes are received from the relevant stakeholders.	N/A	Operational Deficit / Surplus (Rand value)
Infrastructure cost only	Affordability of IPTN infrastructure cost	Affordability of IPTN infrastructure cost	Unit cost for additional infrastructure investment within the next 20 years.	N/A	Capital investment cost (Rand value)

Table 10-6: Economic Assessment Criteria

Criteria Name	Criteria Detail	Reasoning for measuring this item	What is this item comprised of (i.e. input)	Assumptions	What is the output
Travel Time Savings	Comparing the Travel time savings for each alternative	The Travel time savings are the time savings accrued due to an improvement in a system.	In order to determine the TT savings, commuters VOT, and the Transport Demand model output will be used	Use different VOT for different income groups.	Total travel time savings
B/C analysis	Comparing the Benefit/Cost ratios for each of the alternatives	The B/C analysis aims to determine whether an improvement in the transport system yields benefits greater than the cost. This is done by considering the direct benefits and cost related to the improvement	**Benefits:** Travel Time Savings, Vehicle Operation Cost Savings, Accident Cost Savings. **Costs:** Construction Cost, Operating Cost, Maintenance Cost. Use model outputs to determine the travel times per mode as well as the total passengers per OD pair. The vehicle kilometres per mode are also retrieved from the model.	The AMPH outputs from the model will be converted to annual cost and benefits. These benefits and cost will be discounted over a 20 year period at a social discount rate of 8%.	A ratio of (direct) benefits / (direct) cost for each of the network alternatives. Also, the Internal Rate of Return & Net Present Value for each of the network alternatives
Wider Economic Benefits	Compare the wider economic benefits resulting from the capital investment for each alternative.	The wider economic benefits are those indirect benefits that are accrued due to an improvement in the system. This analysis will focus on the multiplier effect. The total GDP multiplier is used for this study which includes the direct, indirect and induced effects on the	Total investment which differentiates between production expenditure, capital and labour.	Assume all exports from outside South African borders are considered "leakages". Only take into account local (South African) labour and differentiate between skilled and un skilled work force.	Total welfare effect (Rand value) due to investment in transport infrastructure.

		economy if an additional unit of output is produced.			

10.3 Multi Criteria Analysis (MCA) process

The Terms of Reference specified that a Multi Criteria Analysis should be conducted on the assessment results to determine the preferred IPTN Alternative.

The process is explained in the sections below.

10.3.1 MCA Weightings

The relative weightings for the different assessment criteria were determined by conducting a pairwise comparison exercise to determine quantitatively the relative importance for each criterion. The weightings were then applied to the ratings of the network alternatives for each assessment criterion which then gave an overall score for each alternative.

The methodology for conducting the pairwise comparison exercise was workshopped with officials from the City of Cape Town in the following Departments to get a representative sample of City officials to weight the relative importance of the assessment criteria:

- TCT Planning
    - Transport Planning
    - Systems Planning and Modelling
    - Business Development
- TCT Infrastructure
    - Public Transport Construction
- Spatial Planning and Urban Design
- Environmental
- Economic Development

Two representatives from each department conducted a pairwise comparison exercise by completing a matrix where the respondents had to choose one criteria over another. This is shown in Figure 10-1 and Figure 10-2 below. Figure 10-1 indicates the empty spreadsheet which the respondent had to complete and Figure 10-2 is an example of a completed pairwise comparison.

Nine completed pairwise comparison exercises were received back from the City officials.

Assessment Criteria			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
Environmental Sustainability	Loss of sensitive habitat	A	-																						
	Total air pollution	B	-	-																					
	Exposure to air pollution	C	-	-	-																				
	Greenhouse gas emission	D	-	-	-	-																			
	Energy efficiency	E	-	-	-	-	-																		
Strategic Economic Assessment	Travel Time Savings	F	-	-	-	-	-	-																	
	B/C analysis	G	-	-	-	-	-	-	-																
	Wider Economic Benefits	H	-	-	-	-	-	-	-	-															
Strategic Transport Assessment	Modal split (public transport users vs total transport users)	I	-	-	-	-	-	-	-	-	-														
	Total vehicle-km per mode	J	-	-	-	-	-	-	-	-	-	-													
	V/C ratio	K	-	-	-	-	-	-	-	-	-	-	-												
	Average travel time	L	-	-	-	-	-	-	-	-	-	-	-	-											
Social Impact Assessment	Avoid resettlement.	M	-	-	-	-	-	-	-	-	-	-	-	-	-										
	Minimise expropriation.	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-									
	Jobs created by construction.	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-								
	Linkages to intermodal transport facilities.	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-							
	Linking residential areas and economic/industrial/commercial hubs.	Q	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-						
	Linking residential areas to social services and facilities, including health, education, security and leisure.	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-					
Alignment with Corporate Plans and Strategies	Investment attraction	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-				
	Safety in Communities	T	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
	Economic opportunity	U	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
Cost Evaluation	Deficit / Surplus (Operations only)	V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	Infrastructure cost only	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Figure 10-1: Pairwise comparison exercise trade-off sheet (empty)

Pairwise Comparison			Assessment Criteria																						
Assessment Criteria			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
Environmental Sustainability	Loss of sensitive habitat	A	-	A	C	A	E	F	G	H	I	J	K	A	M	A	O	A	Q	R	R	T	U	A	W
	Total air pollution	B	-	-	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	R	B	U	B	B
	Exposure to air pollution	C	-	-	-	C	E	F	C	C	C	J	K	C	C	C	C	P	Q	R	R	T	U	V	W
	Greenhouse gas emission	D	-	-	-	-	E	F	G	H	D	D	K	D	D	D	D	O	Q	R	R	D	D	V	W
	Energy efficiency	E	-	-	-	-	-	F	G	H	E	E	K	E	E	E	E	O	Q	R	R	E	U	V	W
Strategic Economic Assessment	Travel Time Savings	F	-	-	-	-	-	-	G	H	F	F	K	F	F	F	F	O	Q	R	R	T	F	F	F
	B/C analysis	G	-	-	-	-	-	-	-	G	G	G	G	G	G	G	G	G	Q	R	R	G	U	V	W
	Wider Economic Benefits	H	-	-	-	-	-	-	-	-	H	H	H	H	M	N	O	H	H	H	H	T	H	H	W
Strategic Transport Assessment	Modal split (public transport users vs total transport users)	I	-	-	-	-	-	-	-	-	-	I	K	L	M	N	I	I	I	R	S	T	I	I	I
	Total vehicle-km per mode	J	-	-	-	-	-	-	-	-	-	-	J	J	J	J	J	P	J	R	S	T	U	J	W
	V/C ratio	K	-	-	-	-	-	-	-	-	-	-	-	L	M	N	O	P	Q	R	S	K	U	K	K
	Average travel time	L	-	-	-	-	-	-	-	-	-	-	-	-	L	N	O	L	L	L	L	T	L	V	W
Social Impact Assessment	Avoid resettlement.	M	-	-	-	-	-	-	-	-	-	-	-	-	-	J	J	J	Q	R	S	T	U	M	M
	Minimise expropriation.	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	K	K	K	R	S	N	U	V	W
	Jobs created by construction.	O	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	P	L	R	S	T	U	V	O
	Linkages to intermodal transport facilities.	P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	P	P	P	T	P	V	W
	Linking residential areas and economic/industrial/commercial hubs.	Q	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Q	Q	T	U	Q	P
	Linking residential areas to social services and facilities, including health, education, security and leisure.	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	T	U	R	W
Alignment with Corporate Plans and Strategies	Investment attraction	S	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	S	S	V	W
	Safety in Communities	T	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	V	T
	Economic opportunity	U	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	U	W
Cost Evaluation	Deficit / Surplus (Operations only)	V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	V
	Infrastructure cost only	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Figure 10-2: Example: Pairwise comparison exercise trade-off sheet (Completed)

Results

The results of each person's pairwise comparison were combined to give the average weighting for each of the assessment criteria (see Table 10-7). The weightings were adjusted to account for the over representation of certain assessments (For example: Environmental Sustainability included four criteria compared to Cost Evaluation only including two criteria). All weightings added up to 100.

Table 10-7: Weightings of Assessment Criteria

Assessment Criteria		Weighting
Environmental Sustainability	Loss of sensitive habitat	4
	Total air pollution	4
	Exposure to air pollution	4
	Greenhouse gas emission	3
	Energy efficiency	4
Strategic Economic Assessment	Travel Time Savings	6
	B/C analysis	7
	Wider Economic Benefits	5
Strategic Transport Assessment	Modal split (public transport users vs total transport users)	5
	Total vehicle-km per mode	4
	V/C ratio	3
	Average travel time	5
Social Impact Assessment	Avoid resettlement.	2
	Minimise expropriation.	1
	Jobs created by construction.	1
	Linkages to intermodal transport facilities.	3
	Linking residential areas and economic/industrial/commercial hubs.	4
	Linking residential areas to social services and facilities, including health, education, security and leisure.	4
Alignment with Corporate Plans and Strategies	Investment attraction	4
	Safety in Communities	7
	Economic opportunity	7
Cost Evaluation	Deficit / Surplus (Operations only)	10
	Infrastructure cost only	5

		100

The result of the weighting indicates that the operational deficit/surplus was considered to be the most important criterion (weight of 10) followed by the economic benefit / cost analysis (weight of 7) and Alignment with corporate plans in terms of safety in communities and economic opportunity (also a weight of 7).

The social assessment criteria had the lowest weights relative to the other assessment criteria.

10.3.2 Rating of Alternatives

The various assessment criteria were extracted from the assessment results discussed under Chapter 9 of this report and rated according to the most and least preferred Transport Alternative for each criteria.

Each Transport Alternative was given a relative rating with the most preferred alternative receiving a rate of one and the other alternatives a proportional rating relative to the preferred alternative according to how each alternative was measured by the assessment criteria, as discussed in chapter 9. .

The values of each assessment criteria obtained from Chapter 9 are shown in Table 10-8 converted to a rating out of 1.00 where 1.00 is the value of the best performing alternative for each specific criterion.

Table 10-8: MCA Ratings of Transport Alternatives

Assessment Criteria		Assessment Value					Rating				
		TA1	TA2	TA3	TA4	TA5	TA1	TA2	TA3	TA4	TA5
Environmental	Loss of sensitive habitat	213	555	571	605	642	1.00	0.38	0.37	0.35	0.33
	Total air pollution	3 769	3 030	2 732	2 791	2 604	0.69	0.86	0.95	0.93	1.00
	Exposure to air pollution	0.07	0.43	0.43	0.44	0.41	1.00	0.15	0.16	0.15	0.16
	Greenhouse gas emission	1 724	1 472	1 291	1 349	1 264	0.73	0.86	0.98	0.94	1.00
	Energy efficiency	24 738	20 979	18 245	19 258	18 020	0.73	0.86	0.99	0.94	1.00
Economic	Travel Time Savings	64 988	59 527	50 614	55 657	50 603	0.78	0.85	1.00	0.91	1.00
	B/C analysis	1	17	19	20	22	0.05	0.79	0.86	0.90	1.00
	Wider Economic Benefits (R'000 000)	R 13 025	R 33 170	R 40 538	R 35 811	R 37 319	0.32	0.82	1.00	0.88	0.92
Transport	Modal split (public transport users vs total transport users)	854 564	843 792	976 566	961 964	976 566	0.88	0.86	1.00	0.99	1.00
	Total vehicle-km per mode	8 434 813	7 304 935	6 289 707	6 668 610	6 289 707	0.75	0.86	1.00	0.94	1.00
	V/C ratio	0.071	0.129	0.076	0.091	0.076	1.00	0.55	0.93	0.77	0.93
	Average travel time	0.14	0.2	0.23	0.2	0.23	0.61	0.87	1.00	0.87	1.00
Social	Avoid resettlement.	0.2	0.2	0.2	0.2	0.2	1.00	1.00	1.00	1.00	1.00
	Minimise expropriation.	0.2	0.2	0.2	0.2	0.2	1.00	1.00	1.00	1.00	1.00
	Jobs created by construction.	0.21	0.19	0.19	0.22	0.19	0.95	0.86	0.86	1.00	0.86
	Linkages to intermodal transport facilities.	0.1	0.15	0.25	0.25	0.25					

							0.40	0.60	1.00	1.00	1.00
	Linking residential areas and econ/indus/com hubs.	0.1	0.15	0.25	0.25	0.25	0.40	0.60	1.00	1.00	1.00
	Linking residential areas to social services and facilities	0.1	0.15	0.25	0.25	0.25	0.40	0.60	1.00	1.00	1.00
Alignment	Investment attraction	19 193	66 090	84 265	63 804	80 419	0.23	0.78	1.00	0.76	0.95
	Safety in Communities	245	1244	1378	586	1040	0.18	0.90	1.00	0.43	0.75
	Economic opportunity	1015	1083	1123	657	977	0.90	0.96	1.00	0.58	0.87
Cost	Deficit / Surplus (Operations only) (R'000 000)	R 2 484	R 6 455	R 3 650	R 2 101	R 1 448	0.58	0.22	0.40	0.69	1.00
	Infrastructure cost only (R'000 000)	1	R 17 794	R 25 039	R 21 349	25 039	1.00	0.00	0.00	0.00	0.00

10.3.3 MCA Results

The ratings in Table 10-8 above were then multiplied by the weights for each assessment criteria. Table 10-9 shows the MCA results.

Transport Alternative 5 is considered to be the preferred IPTN Alternative according to the overall MCA results followed by Transport Alternative 3.

The MCA results also indicate that all the proposed alternatives (TA2-TA5) score better than the “Do-minimum” Alternative (TA1).

TA 1 performs best in the Environmental Assessment criteria with TA2 being the worst. In both the Economic and Transport Assessments TA5 scores the highest followed by TA3. TA1 scores the worst for all assessments accept for Environmental and Cost of Infrastructure. In the Social Assessment TA4 scores the highest followed by TA3 and TA5. TA3 scored the highest rating for the Alignment with corporate plans followed by TA2.

Table 10-9: Multi Criteria Analysis Result

	Assessment Criteria	Weighting	Rating					Weighted Score				
			TA1	TA2	TA3	TA4	TA5	TA1	TA2	TA3	TA4	TA5
Environmental	Loss of sensitive habitat	4	1.00	0.38	0.37	0.35	0.33	3.9	1.5	1.5	1.4	1.3
	Total air pollution	4	0.69	0.86	0.95	0.93	1.00	2.7	3.4	3.7	3.7	3.9
	Exposure to air pollution	4	1.00	0.15	0.16	0.15	0.16	4.3	0.7	0.7	0.7	0.7
	Greenhouse gas emission	3	0.73	0.86	0.98	0.94	1.00	2.4	2.8	3.2	3.1	3.3
	Energy efficiency	4	0.73	0.86	0.99	0.94	1.00	2.9	3.4	3.9	3.7	3.9
	Total Score							**16.22**	**11.73**	**12.95**	**12.43**	**13.12**
Economic	Travel Time Savings	6	0.78	0.85	1.00	0.91	1.00	4.6	5.0	5.9	5.4	5.9
	B/C analysis	7	0.05	0.79	0.86	0.90	1.00	0.3	5.2	5.7	5.9	6.6
	Wider Economic Benefits (R'000 000)	5	0.32	0.82	1.00	0.88	0.92	1.6	4.2	5.1	4.5	4.7
	Total Score							**6.53**	**14.37**	**16.66**	**15.78**	**17.16**
Transport	Modal split (public transport users vs total transport users)	5	0.88	0.86	1.00	0.99	1.00	4.1	4.0	4.7	4.6	4.7
	Total vehicle-km per mode	4	0.75	0.86	1.00	0.94	1.00	2.8	3.3	3.8	3.6	3.8
	V/C ratio	3	1.00	0.55	0.93	0.77	0.93	3.2	1.8	3.0	2.5	3.0
	Average travel time	5	0.61	0.87	1.00	0.87	1.00	3.1	4.5	5.1	4.5	5.1
	Total Score							**13.25**	**13.51**	**16.57**	**15.12**	**16.57**
Social	Avoid resettlement.	2	1.00	1.00	1.00	1.00	1.00	2.0	2.0	2.0	2.0	2.0
	Minimise expropriation.	1						0.8	0.8	0.8	0.8	0.8

			1.00	1.00	1.00	1.00	1.00					
	Jobs created by construction.	1	0.95	0.86	0.86	1.00	0.86	0.8	0.7	0.7	0.9	0.7
	Linkages to intermodal transport facilities.	3	0.40	0.60	1.00	1.00	1.00	1.3	1.9	3.2	3.2	3.2
	Linking residential areas and econ/indus/com hubs.	4	0.40	0.60	1.00	1.00	1.00	1.4	2.1	3.5	3.5	3.5
	Linking residential areas to social services and facilities	4	0.40	0.60	1.00	1.00	1.00	1.5	2.2	3.7	3.7	3.7
	Total Score							**7.76**	**9.77**	**13.96**	**14.08**	**13.96**
Alignment	Investment attraction	4	0.23	0.78	1.00	0.76	0.95	0.9	3.1	3.9	3.0	3.8
	Safety in Communities	7	0.18	0.90	1.00	0.43	0.75	1.2	6.1	6.8	2.9	5.1
	Economic opportunity	7	0.90	0.96	1.00	0.58	0.87	6.0	6.4	6.6	3.9	5.8
	Total Score							**8.10**	**15.63**	**17.38**	**9.76**	**14.67**
Cost	Deficit / Surplus (Operations only) (R'000 000)	10	0.58	0.22	0.40	0.69	1.00	5.6	2.2	3.8	6.7	9.7
	Infrastructure cost only (R'000 000)	5	1.00	0.00	0.00	0.00	0.00	5.1	0.0	0.0	0.0	0.0
	Total Score							**10.77**	**2.17**	**3.83**	**6.65**	**9.66**
Total		100						**62.64**	**67.18**	**81.36**	**73.83**	**85.14**

10.3.4 MCA Sensitivity Testing

A sensitivity analysis was conducted to evaluate the effect on the MCA results by changing the weights as well as eliminating certain assessment criteria.

The following sensitivity testing was conducted.

1. Set all weights equal (each criteria scores a weight of 4)
2. Eliminate certain criteria to reduce the effect of possible double counting. The following criteria were eliminated:
    - Environmental - Greenhouse gas emission
    - Economic – Wider Economic Benefits
    - Transport – Travel Time
    - Social – Avoid Resettlement and Jobs created by Construction

Table 10-10 below shows the MCA sensitivity results. The results show that the preferred IPTN Alternative (TA5) remains the preferred alternative.

Table 10-10: MCA sensitivity analysis

Sensitivity - Score	TA1	TA2	TA3	TA4	TA5
All Weightings equal	64.46	68.84	83.72	78.69	85.14
Eliminate similar criteria	62.43	61.33	77.27	70.80	82.53

10.4 Preferred IPTN Alternative

After careful consideration Transport Alternative 5 (TA5) was selected as the preferred IPTN alternative. Figure 10-3 illustrates the preferred IPTN alternative.

This preferred alternative has been improved by adding the following elements to TA5:

- It is proposed that land should be reserved for the Chris Hani Rail extension should the proposed PTOD land use scenario realise in Somerset West. This rail extension will be required when trunk route T10 reaches its capacity.

  The transitional proposals for currently contracted bus services and unscheduled minibus taxi services will be addressed in detail in the Operational and Implementation Plans.

It was confirmed that the scheduled services in the preferred IPTN alternative aims to serve 80% of the population within 500m of a station or stop as shown in Figure 10-3.

It is proposed that unscheduled demand-responsive services be provided to the 20% of the population not served within 500m of scheduled public transport services as part of the capillary network (see section 5.8).

The preferred Integrated Public Transport Network (TA5 with the improvements listed above) consists of the following routes:

10.4.1 Infrastructure

Rail
The new infrastructure required for the assumed additions to the existing rail network consists of:

- Blue Downs line between Nolungile and Kuilsrivier stations.
  - It is assumed that this new line, which is about 9km long, will be electrified and consist of a double track with three stations along its length, at Mfuleni, Blue Downs and Wimbledon.
  - At the southern end, the line should include connections to/from Nolungile station and to/from Nonkqubela station.
  - At the northern end, connections will only permit trains to operate to/from Kuilsrivier Station and not to/from Blackheath station.
- It is proposed that land should be reserved for the Chris Hani Rail extension should the proposed PTOD land use scenario realise in Somerset West.
- Rail Modernisation occurs
- Eersterivier - Strand rail line requires doubling
- Additional stations are implemented at Bloekombos and Philippi West

Road
The following improvements are required to the existing road network for the provision of median busways for the proposed BRT routes:

New Roadways

BRT Routes.

- Extension of Giel Basson Drive(M12) from Sienna Drive north of Burgundy Estate and Richwood, over the M13 and N7, linking with Potsdam Road and extending west-wards on the new bridge over the rail to link with Sandown Road, then northwards to a new development and westwards to a terminus in Big Bay. This route will ultimately be a four-lane dual carriageway road with dedicated median bus lanes and ap-proximately 5 stations from Plattekloof Road to Sandown Road;
- Extension of Prestige Drive northwards from Voortrekker Road through Maitland and provision of a new busway viaduct over the rail lines west of Kentemade station, with ramps from the viaduct down to ground between the rail lines and the N1. The east facing ramp will serve the BRT route to Century City via the Sable Road bridge over the N1 and the west facing ramp from the viaduct will serve a new busway leading under the Koeberg interchange bridges and over the Salt River Canal to connect with the existing Phase 1 busway to the Civic Centre on the south side of its under-pass under the N1;
- Extension of Frans Conradie Drive (M25) from Vanguard Drive westwards through Wingfield and over the rail line at Century City station to link with the bridge over the N1 at Sable Road.

- A new road (Nigeria Way), with dedicated bus lanes, linking Valhalla Drive and Jan Smuts Drive along the southern side of Epping Industrial between the rail line and Bofors Circle, passing underneath Vanguard Drive at the rail bridge;
- Extension of Ottery Road west of the M5 into a new carriageway along the southern side of South Road through to Main Road, with a planned rail underpass south of Wittebome Station;
- New Link from Baden Powell Drive, west of the Coastal Park landfill site, to the proposed alignment of the M42 (eastern extension of Steenberg Road)between Vrygrond and Lavender Hill, linking with the M5. Alternatively, the link from Baden Powell Drive to the extension of Military Rd in Lavender Hill;
- New road to link Charl Malan Drive (Bellville) to Durban Rd, via Kort St and Maree St, as an alternative to providing bus lanes in Voortrekker Rd and Durban Rd through the Bellville CBD.
- Extension of Hindle Rd to Melton Rd in Blue Downs.

Distributor and Feeder Routes

One distributor route is included. This operates in partially mixed traffic and existing dedicated bus lanes as follows:

- D02 from Mitchells Plain to Cape Town CBD via Klipfontein Road, Main Road and Victoria Road.
- The feeder routes operate in mixed traffic with priority measures at congested intersections.

Existing roadways

BRT Routes

The following routes form part of the proposed IPTN :

<u>T01 (MyCiTi Phase 1): Dunoon - Table View - Civic Centre – Waterfront</u>

Usasaza Station, Potsdam Road, Blaauwberg Road, Table View Station, Blaauwberg Road, Marine Drive, Milner Street, Paarden Eiland busway, Culemborg bus lane, Hertzog Boulevard, Civic Centre Station, Hertzog Boulevard, Heerengracht, Hans Strijdom Avenue, Western Boulevard, Granger Bay Boulevard, Granger Bay Road, Breakwater Boulevard, Waterfront Station.

<u>T02 (MyCiTi Phase 1): Atlantis – Table View – Civic Centre</u>

Atlantis Station, Reygersdal Drive, Dassenberg Road, West Coast Road, Melkbosstrand Road, Otto Du Plessis Drive, Melkbosstrand Station, Birkenhead Drive, West Coast Road, Blaauwberg Road, Table View Station, Blaauwberg Road, Marine Drive, Milner Street, Paarden Eiland busway, Culemborg bus lane, continue Hertzog Boulevard, Civic Centre Station.

T03 (MyCiTi Phase 1): Atlantis – Table View – Century City

Atlantis Station, Reygersdal Drive, Charel Uys Drive, Dassenberg Road, West Coast Road, Melkbosstrand Road, Otto Du Plessis Drive, Melkbosstrand Station, Birkenhead Drive, West Coast Road, Blaauwberg Road, Table View Station, Blaauwberg Road, Marine Drive, Race-course Road, Omuramba Road, Ratanga Road, Century Link, Century Way, Century City Public Transport Transfer station.

T04 (MyCiTi Phase 1): Du Noon – Century City

Usasaza Station, Potsdam Road, Koeberg Road, Racecourse Road, Omuramba Road, Ratanga Road, Century Boulevard, Century Way, Century City Public Transport Transfer station.

T10: Gordon's Bay -Strand – Khayelitsha – Mitchell's Plain – Strandfontien – Steenberg – Retreat

Sir Lowry Rd, Mountainside Boulevard , Grens Weg, R44 Gordon's Bay Drive, Strand Station terminus, Main Rd through Somerset West, Broadway Blvd, M9, Steve Biko Rd, Ngcwalazi Drive, Spine Rd, AZ Berman Dr, *(Wespoort Dr, Weltevreden Rd, Spine Rd, Strandfontien Rd, Baden Powell Dr), new link, M5, Military Rd, Main Rd, terminus at Retreat Station.

**Alternative alignment subject to relevant Philippi Horticultural Area development: … Wespoort Dr, Vanguard Dr, new west extension of Morgenster Dr, Strandfontein Rd, Baden Powell Dr, …*

T11: Wynberg – Lansdowne – Khayelitsha
Wynberg Station access, Main Rd/Brodie Rd couplet, South Rd new carriageway, Ottery Rd, Strandfontein Rd, Govan Mbeki Rd (M9),Jeff Masemola Rd, Spine Rd, Walter Sisulu Rd, Khayelitsha Station access, Steve Biko Rd, Govan Mbeki Rd, Oscar Mpetha Rd, Mew Way, Baden Powell Dr, Walter Sizulu Rd, Chris Hani Station terminus.;

T12: Claremont – Lansdowne – Mitchell's Plain
Claremont Station terminus, Stanhope Rd, Imam Haron Rd, Chichester Rd, Doncaster Rd, Race Course Rd, Turfhall Rd, Jan Smuts Dr, Govan Mbeki Rd (M9), Jeff Masemola Rd, Stock Rd, AZ Berman Dr, Wespoort Dr, 1st Ave, Mitchell's Plain CBD Terminus, Imperial St, AZ Berman Dr, Kilimanjaro St, Yellowwood St, Kapteinsklip Station terminus;

T13: Mitchell's Plain – Symphony Way – Bellville – Durbanville
Kapteinsklip Station, Merrydale Ave, Eisleben Rd, New Eisleben Rd, Jeff Masemola Rd, Symphony Way, Robert Sobukwe Rd, Belrail Rd, Bellville PT Interchange, Charl Malan St, Voortrekker Rd, Durban Rd (alternatively new link via Kort St extension), Willie Van Schoor (northwards)/ Durban Rd (southwards), Durbanville Ave, Main Rd, Wellington Rd, New Street Terminus.

T14: Westlake - Retreat – Hanover Park – Epping – Parow
Bell Crescent terminus, Steenberg Rd, Main Rd, Station Rd, Concert Blvd, Retreat Rd, 5th Ave, Strandfontien Rd, Govan Mbeki Dr, Hanover Park Ave, Turfhall Rd, Pooke Road, Hazel Road, Klipfontein Road, Duinefontein Road, Valhalla Drive,Viking Way, Avonwood Ave, Francie van Zijl Dr, Mike Pienaar Rd, Voortrekker Rd, Charl Malan St, Bellville Terminus.

T15: Strandfontien – Pelikan Park – Athlone – Pinelands – Maitland – CBD
Spine Rd terminus, Strandfontien Rd, Jan Smuts Dr, Prestige Dr extension, new viaduct over rail lines, link to MyCiTi Phase 1A busway along south side of N1, Civic Station.

T16: Eersterivier – Blue Downs – Delft – Parow – Monte Vista –Bothasig – Parklands – Big Bay
Eersterivier Station, Bosman St, Stasie Rd, Van Riebeeck Rd, Forest Dr, Hindle Rd, new extension to Hindle Rd (M54), Symphony Way, Jeff Masemola Rd, New Eisleben Rd, Klipfontein Rd, Borcherds Quarry Rd, Robert Sobukwe Rd , 35th Ave, Jan Van Riebeeck Dr, Giel Basson Dr, new road over N7, Potsdam Rd, new east-west road link towards Big Bay

T17: Khayelitsha – Klipfontein – Epping – Maitland – Century City
Khayelitsha Station, Steve Biko Dr, Mew Way, Jeff Masemola Rd, New Eisleben Rd, Klipfontein Rd, Borcherds Quarry Rd, Robert Sobukwe Rd, Valhalla Drive, Nigeria Way (a new road south of Epping Industrial), Jan Smuts Drive, Prestige Drive extension (viaduct over rail lines), new busway along the side of N1 into Sable Rd, Ratanga Rd, Century Blvd, Century Ave, Montague Dve, Koeberg Rd, Omuramba Rd, Omuramba Station

T19: Wallacedene – Durbanville – Bellville – Parow – Century City
Bloekombos new rail station, Old Paarl Road, Van Riebeeck St, Langeberg Rd, Wellington Rd, Durbanville Ave, Durban Rd, Frans Conradie Dr, new road through Wingfield to Sable Rd, Ratanga Rd terminus station

Facilities

BRT Terminals

Each of the BRT routes will require a closed terminal station at either end of the route at which space should be provided for buses to wait for departure time (lay-over) before approaching the loading platform and provision must also be made for the vehicles to turn around and change direction. In addition, sufficient feeder drop-off and loading platforms will need to be provided. Table 10-11 is a provisional list of such facilities, including intermediate transfer terminals where several trunk routes, including rail, may interface:

Table 10-11 - BRT Terminals

Name of Terminal	Location	Interfa	Rapid bus lines	Lay-over
Strand Station	Main Road, Somerset West	Yes	T10	Yes
Westlake	Bell Crescent, Westlake	No	T10, T14	Yes
Wynberg	Morom Road, Wynberg	Yes	T11	Yes
Khayelitsha	Khayelitsha Mall, Walter Sisulu Rd,	Yes	T10, T11, T17	Yes
Claremont	Newry St, Claremont	Yes	T12	Yes
Mitchell's Plain	1st Avenue/Alpha St.	Yes	T10, T11, T12, T13	Yes

Name of Terminal	Location	Interfa	Rapid bus lines	Lay-over
Bellville PTI	Charl Malan Street	Yes	T13, T14	Yes
Durbanville	New Street, Durbanville	No	T13	Yes
Retreat Station	Station Way, Retreat	Yes	T14	Yes
Strandfontien	Cnr Spine Road and Trafalgar Dr	No	T10, T15	Yes
Eersterivier Station	Stasie Road Eersterivier	Yes	T16	Yes
Sandown Rd	R27/Sandown Road East	No	T03, T04, T16	Yes
Century City	Ratanga Road	No	T17,T19	Yes
BloekombosStation	Wallacedene	Yes	T19	Yes

Closed route stations

Each BRT route will require stations that are located in the median, strategically spaced to support the land use, pedestrian desire lines and interfaces with feeder routes. The preliminary locations of these are based on an average spacing of 800m but each station site is selected based on the route requirements, intersections and adjacent land use. The final locations of the stations will be subject to the conceptual design of each route.

Open stops

In some areas it is not possible, without drastic property acquisition, to incorporate closed median stations into the road reserve. In these areas the BRT buses will operate on the left side of the roadway, with appropriate priority measures at intersections, and will load and disembark passengers at kerbside stops. The buses on the routes where this is the case, will be fitted with fare validators at the left hand door adjacent to the driver.

Feeder stops

For modelling and costing purposes an average spacing of 500m between feeder stops has been used.

10.4.2 Services

Rail

The duration of rail services is assumed to be 18 hours on all routes with the exception that those rail services that have very low demand in the first and last hours of the daily service are reduced to 16 hours of service duration. The frequency of service is assumed to be provided according to the variation in demand throughout the day, with a minimum headway of 3 minutes between trains in the peak hours and a maximum headway of 20 minutes in off-peak periods.

It has been assumed that all the existing train sets will have been replaced by the new PRASA rolling stock which is currently being manufactured and will be delivered to replace existing old train sets over a 10 year period commencing in 2016. Information obtained from PRASA indicates that the new 12 coach train sets will have a maximum passenger capacity of 2,430 for Metro class.

Road

The operating deficit has been reduced significantly from that shown in the other alternatives by limiting the supply of BRT services to 90 second headways in the peak periods to effect a spreading of the high peak hour demand so that buses are able to run full for at least two hours in each of the morning and afternoon peak periods.

During the off-peak periods, where the demand is less than 65% of the capacity provided by buses running at a headway of 20 minutes, this demand can be carried by buses running at a headway of 30 minutes, which contributed to a 33% reduction in the vehicle running costs.

Although most of the feeder services are scheduled in this alternative, 20% of the feeder routes are allocated to unscheduled services. These unscheduled services are primarily on the Stellenbosch and Strand/Somerset West area.

The duration of the scheduled road services (BRT trunk and feeder) are assumed to operate for 18 hours of the day, but similarly to rail, low demand in the first and last hour of the daily operations can result in 16 hour services on those routes.

Scheduled services (BRT-Trunk and scheduled feeders)

Hours of operation

For the 2032 demand and cost modelling of TA5, most routes were assumed to operate between the hours of 04:00 and 22:00 (18hrs) 7 days per week, but a reduced frequency is assumed on weekends for the cost modelling. Low demand on the first and last hours of the day resulted in a 16 hour service on these routes.

Types of vehicle

The 2032 demand modelling was done with the following vehicle sizes for the different types of services:

- Trunk routes – 18m low floor articulated buses – 110 passenger capacity,
- Distributor routes – 12m low entry buses – 80 passenger capacity,
- Scheduled feeder routes – 9m low entry buses – 45 passenger capacity.

All these bus types will have doors on both sides of the vehicles so that they can serve passengers at either left side open stops are right side closed median stations.

Headways

An initial headway of 5 minutes was used in the 2032 peak hour model for all scheduled trunk, distributor and feeder services. Depending on the resulting demand on each route, the model determined the headway required to serve the calculated peak hour passenger with the specified vehicle size for each route.

If the headway required to serve the peak hour passenger demand on trunk routes is calculated by the model to be less than 90 seconds, double platform median closed stations will have to be provided for more than one bus to stop simultaneously, to prevent buses queuing. Passing lanes will also need to be provided at all stations. In this alternative, by limiting the headway to 90 seconds, single platforms will be sufficient at most stops, except where 2 or more BRT routes interface to enable transfers. At these stations, a platform needs to be provided per route as well as an additional platform for feeder buses.

If the passenger demand on feeder routes indicates that headways of 5 minutes is not sufficient with a 9m bus, a 12m bus will then be used on this route.

Unscheduled services

Hours of operation and headways

The hours of operation and headways are determined by the operator and are expected to follow demand, particularly in the peak periods. Off-peak services cannot be guaranteed to passengers unless the operator deems it viable to operate during these times. Unscheduled services, by their nature do not have specified headways and vary.

Types of vehicle

The unscheduled services are assumed to be operated by 6m mini- and midi-buses of 15-30 passenger capacity

These bus types are assumed to only have doors on the left side (kerb-side) of the vehicle and they are not assumed to all be universally accessible.

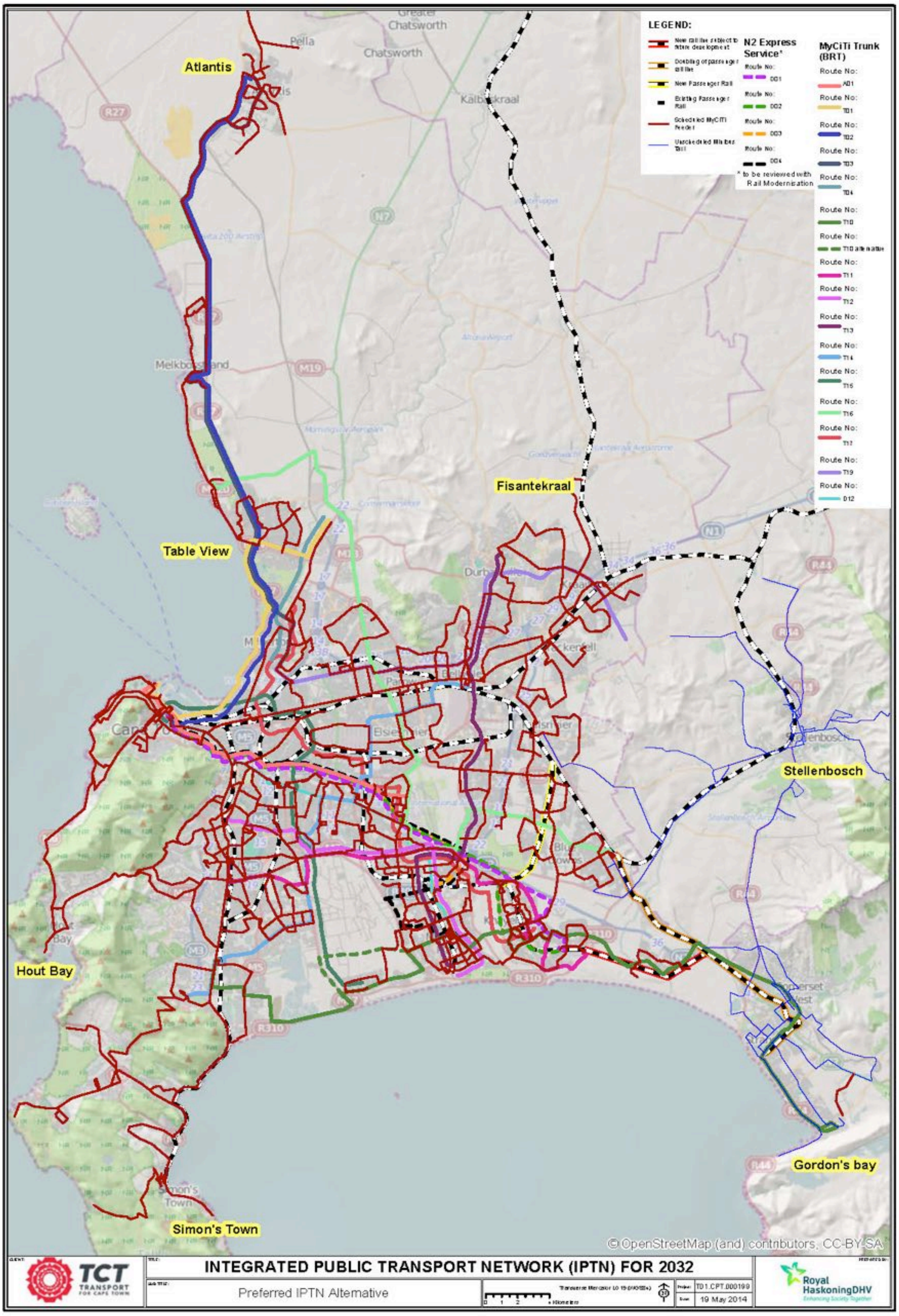

Figure 10-3: Preferred IPTN Alternative

11. Recommendations

Based on the processed followed and the selection of the preferred Integrated Public Transport Network, it is recommended that:

a) This proposed IPTN (TA5) will be Transport for Cape Town's (TCT) 2032 public transport network plan and will form the system planning base for public transport corridor identification and associated projects and for any public transport-related agreements with affected stakeholders, and will further form the basis of:

   i. The IPTN operational plan which will provide operational detail with respect to level of service on the identified routes. This operational plan will be submitted to Council towards the end of 2014;

   ii. The IPTN implementation plan which will provide a roll-out plan detailing the phased implementation of the IPTN towards 2032. This implementation plan will be submitted to Council towards the end of 2014;

   iii. The IPTN business plan which will, in detail, report on both the economic and financial assessment of this preferred IPTN. This business plan will be submitted to Council by mid-2015;

b) Notwithstanding the fact that this 2032 IPTN was developed in terms of a pragmatic Transit Orientated Development (PTOD), the TOD Comprehensive land use assumptions and principles as detailed in Table 4-1 be adopted as the basis for the development of the TOD Comprehensive (TODC) land use scenario. This land use scenario will be applied to the Preferred IPTN (TA5) to assess the impact of more comprehensive transit-oriented development occurring by 2032.

c) The 2015 review of the IPTN, assess and report on the impacts of the TOD Comprehensive land use scenario as developed as per recommendation b) above and may include any refinements stemming from the IPTN operational, implementation and business plans as described in a) above;

d) This proposed IPTN (TA5) be updated every five (5) years to account for updated transport data and behaviour, updated transport demand modelling and business planning, land use changes and alignment with corporate, provincial and national plans and strategies.