

# Possibilities of Integrating Motorized Transportation and Non-Motorized Transportation in the City of Johannesburg

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## 1 ABSTRACT

Developed countries around the world has great functioning public transportation systems, that include integration of innovative public transportation and non-motorized transportation creating smooth and seamless travelling in their cities for commuting. City of Johannesburg has numerous modes of public transportation to create convenient travelling across the city, and more innovative public transport systems are being implemented to ensure that the city has the world class transportation including the development of non-motorized transportation infrastructure such as cycling lanes and pedestrian sidewalks. However, there is a challenge of integration between motorized transportation, specifically, innovative public transport (Bus Rapid Transit system (Rea Vaya) and High-speed Rail (Gautrain system)) and non-motorized transportation. This paper aims to assess the possibility of integrating non-motorized transportation and Innovative public transportation, and the level of cycling to switch from bicycle to innovative public transportation by commuters to complete a journey in the City of Johannesburg. The study adopted qualitative research design that facilitated the gathering and analysis of spatial and qualitative data from the innovative urban public transport officials, commuters and the cyclists. The results revealed that there is a possibility of spatial integration between non-motorized transportation and innovative public transportation in different parts of the city. Cycling lanes and pedestrian sidewalks have a direct access to Rea Vaya stations and Gautrain stations, however, there is no development of bicycle parking next to Gautrain stations and Rea Vaya stations. Spatial access of a commuter from Gautrain station to Rea Vaya station is 74,5 metres in Johannesburg Park station were there is visible spatial integration in the city. The paper concludes that there is insufficient cycling across the city, no bicycle parking spots next to innovative public transportation station, no recognised integration between innovative public transportation and non-motorized transportation, commuters either walk or drive private vehicles to Rea Vaya or Gautrain stations. The study recommends the development of bicycle parking stations next to innovative public transportation stations to encourage the usage of cycling, and institutional integration of innovative public transportation to create swift transportation for commuters. Further, development of more non-motorized transportation policies and legislative frameworks that will support and encourage non-motorized transportation and integration of non-motorized transportation and motorized transportation.

Keywords: Non-motorized transport; Innovative public transportation; spatial integration; commuters.

## 2 INTRODUCTION

South Africa is a developing country on the right path to world class public transportation. Initiatives such as implementation of innovative public transport such as Bus Rapid Transit and High Speed Rail have been developed in the republic. Consequently, implementation of non-motorised transportation (NMT) have been visible as there are various cities across the country that have developed cycling lanes and pedestrian sidewalks as some connect people from home to public transport stations and from public transport stations to areas of interest such as areas affording economic opportunities. The above mentioned perspective of implemented strategies are developed to move the republic's public transportation to world class transportation system. Many developed countries globally have well tailored intergrated non-motorized transportation and public transportation that the two concepts of transportation connects swiftly from non-motorized transportation to public transportation, and these strategies are used to encounter many challenges that arise from transportation hence world class cities have such transportation techniques and have been working well. The City of Johannesburg (COJ) is moving towards a world class city, hence, adoption of world class strategies in its transportation planning. Evidence to this, Bus Rapid Transit known as Rea Vaya system, high speed rail has been developed known as Gautrain system operating across three metropolitan municipalities in the Gauteng province which both these public transportation systems are innovative. Consequently, the city has development of cycling lanes in many locations in the City of Johannesburg

municipality together with pedestrian side walks. There is a high need to move from daily use of private motorized vehicles in the City of Johannesburg to combat traffic congestion, air pollution, high rate of car accidents and the use of public transportation have certain benefits such as less stress with driving and free from car accidents, less worrying of finding parking spot, bypass traffic through special lane such of Rea Vaya system, very cheap than owning a private vehicle and operating one. The paper aims to assess the possibility of integrating non-motorized transportation and innovative public transportation (innovative PT), and the level of cycling to switch from bicycle to innovative public transportation by commuters to complete a journey in the City of Johannesburg. Further, develop a model that will inform NMT and innovative PT.

### 3 LITERATURE REVIEW

#### 3.1 Public transportation

Public transportation is a very important factor for the movement of people from origin to destination. It makes the movement of people simple and saves time. However, there are various factors that influence people to switch from urban public transport to private vehicles. These factors are caused by the dynamics of a trip such as travel time, trip motive, and frequent commuting. Further, demographic characteristics has an importance influence such as the level of income, gender and age. As the level of income and age increase, there is a switch that happens from urban public transport to private motor vehicles. Consequently, the most common factors leading to switch from urban public transport to private vehicle use and that makes owners of private vehicle users not to switch to urban public transport are; lack and easy connection for both long and short travelling from origin to destination, switching from one mode to the other mode that are not integrated which have high price costs, access from home or place of interest to the urban public transport station and the quality of service by service providers. Lack of well-tailored systems and network of urban public transportation it's a global challenge hence researchers, policy makers, Transport planners have been developing strategies to produce an effective integrated multimodal system (Maxwell, 1999, Ibrahim, 2003, Vassallo et al., 2012).

#### 3.2 Non-motorized transportation

Non-Motorized Transportation (NMT) includes all forms of travel that do not rely on an engine or motor for movement. This include walking and bicycle, and using small-wheeled transport (skates, skateboards, push scooters and hand carts) and wheelchair (Mat Yazid et al., 2011). The importance of NMT is the provision of door-to-door transport; Non-motorized infrastructure usually has a very high spatial penetration; Non-motorized do not lead to waiting times compared with waiting at public transport stops; Non-motorized have a favorable environmental performance; they are cheap transport modes; Non-motorized are essential elements in multimodal transport chains; Non-motorized provide healthy activities (Rietveld, 2001).

In Cape Town, Nairobi and Dar es Salaam, the cities that are relative to the City of Johannesburg, broader transport policies and strategies do include some attention to NMT; both Cape Town and Nairobi have, in addition, developed stand-alone NMT policies. Among the vision statements of the case cities are the following intentions:

- To create a safe, cohesive and comfortable network of footpaths and cycling lanes/tracks that include shade to develop laws and regulations to ensure prioritization of NMT facilities
- To promote investment in walking and cycling infrastructure
- To connect public transport with walking and cycling facilities
- To influence land-use planning and resettlement patterns to achieve easy access to amenities
- To promote a changed culture that accepts the use of cycling and walking as a means to move around in the city (Iacono et al., 2010).

Increasing the modal share of NMT is possible in any country; however the successfulness depends on many country-specific factors, including climate, geography, culture, political commitment, public awareness, policy effort and consistency, long-term vision and the attractiveness of the alternatives. Several of these are interdependent, and as shown by the example of Bogotá, strong NMT policies, awareness campaigns and political commitment can bring about a shift in public attitudes towards NMT and a 4-fold increase in cycle

trips (Witting et al., 2006; IPCC, 2007). Further, the use of NMT has greater benefit environmentally, economically and socially which this is one of the critically reasons to promote and implement it.

Environmental	Social	Economic
Air quality improvement	Congestion reduction	NMT, particularly cycling, is easy, flexible, cheap and fast.
GHG emission reduction	Health benefits due to exercise. For example, cycling for 30 minutes a day reduces the chance of cardiovascular disease and diabetes by 50% (Witting et al., 2006) Gender benefits: cycling can be particularly suitable for the many short trips women in developing countries take  Social equality and poverty reduction: cheap, fast and reliable transport opportunities, and public space development directed towards all segments of society (ICE, 2000) Noise reduction	More attractive cities for tourists and residents, particularly if car-free zones are included  Reduced travel times due to improved traffic flow  Energy security due to lower vehicle energy use  Safety: increase in bicycle use is often accompanied by a reduction in cycling accidents and an increase in safety in public areas (Vanderbulcke et al., 2009; Witting et al., 2006)

Table 1: NMT Benefits [Source: IPCC, 2007]

### 3.3 Integrated public transportation and non-motorized transportation

Integration of non-motorized transportation makes commuting easier for commuters and allow easy accessibility to places of interest. The below figure illustrates integration of motorized transportation and non-motorized transportation. Commuting is convenient when there is accessibility to public transportation. Consequently, public transportation commuting involves non-motorised transportation allowing movement from home to public transportation and from public transportation to destination.

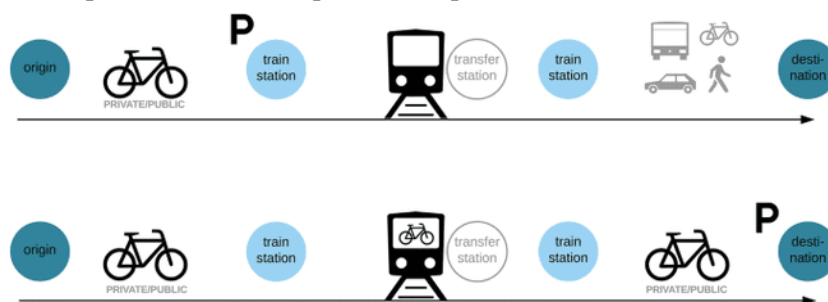


Figure 1: NMT and MT integration [Source: van Mil et al., 2021]

According to Hall (2006) Integration between different services with fixed routes is not anything new. For example, busses arriving at train stations, even with coordinated timetables between the two transportation modes have been around for quite some time. The problem of scheduling an integrated service consisting of two fixed route services, train and bus, operated by two different operators are for example studied in Li & Lam (2004). Also in Martins & Pato (1998) a combination of train and bus services is studied. The problem is to design a feeder bus network given a rail network, with the objective to minimize a cost function considering both the operator's and the customers' interests. A well integrated public transportation system both rail and road makes easier for more tailored transportation system that include non-motorized transportation. Movement from origin by cycling and switching to public transportation makes commuting easier and attract more users to public transportation, and further, if there are less delays within the public transportation services.

### 3.4 South Africa NMT and public transportation policy and legislative frameworks

The Republic of South Africa has various policies and legislative frameworks that facilitate and regulate public transportation, and few policies and legislative frameworks that focuses more on non-motorized transportation. However, some of the public transportation policies and legislative frameworks also include non-motorized transportation but a little is mentioned. Below, it is the policies and legislative frameworks that addresses both national public transportation and non-motorized transportation.

#### 3.4.1 White Paper on National Transport Policy, 1996

One of the policy principles of the White Paper is "to encourage, promote and etc.plan for the use of non-motorised transport where appropriate" (Land Passenger Transport Chapter, Strategic Objectives). The White Paper also states that "the use of more energy-efficient and less pollutant modes of transport will be

promoted. Greater energy awareness will be fostered in both planners and users of land passenger transport through public awareness programmes, differential fuel prices, etc.”

#### 3.4.2 National Land Transport Strategic Framework, 2006 (NLTSF)

The framework provides a sound basis for the promotion of NMT, and strategies and actions are provided in order to achieve this. The NLTSF suggests that planning authorities need to build, expand and maintain continuous networks of formal walkways (sidewalks, off-road paths, safe crossings, and the like.) and dedicated bicycle lanes along lines of high demand. To achieve this, transport plans should assess the status quo and the needs for NMT infrastructure and plan for its design, implementation and maintenance.

- Planning for NMT needs will consider NMT both as a main mode and as a feeder mode linking communities to public transport facilities.
- In rural areas, off-road footpaths, trails and tracks need to be included in the scope of planned rural transport infrastructure.
- In rural areas, animal-drawn carts and other intermediate means of transport will also be supported in transport plans where appropriate. The NLTSF also indicates that walking and cycling should be promoted as the preferred modes in South Africa for appropriate distances and this can be realised through the following:
  - Government actively promotes walking and cycling with the expanded provision of NMT infrastructure as the preferred modes of transport over the appropriate distance ranges for these modes.
  - Where people are walking excessively long distances on their routine journeys, transport plans should assess the scope for measures to support cycling, particularly for scholars. Both infrastructural measures and supporting services such as bicycle repair services should be considered.
- Successful demonstration projects promoting NMT are initiated and rolled out to other areas.

#### 3.4.3 Public Transport Strategy and Action Plan, 2007

This is a central policy document on public transport, highlighting the creation of integrated rapid public transport networks (IRPTNs), wherein NMT is the key aspect of the ‘first mile’ and ‘last mile’ of a trip. The intention is to introduce public transport that would reduce unacceptable walking distances and improve NMT links to public transport. The Public Transport Strategy discusses “high quality non-motorised transport networks”. It provides that NMT, particularly walking and cycling, will serve as an important mode of transport in the proposed IRPTNs. It provides that actions to improve NMT linkages fall into typical infrastructure development categories of planning, design, implementation and maintenance.

#### 3.4.4 Department of Transport (DoT) Draft Policy Document on NMT

This policy states that the DoT will cooperate with relevant government departments and stakeholders in developing an institutional and legal framework that responds positively to the needs and implementation of the NMT system. This policy states that the primary objectives are, amongst others, to:

- Increase the role of NMT as one of the key transport modes,
- Integrate NMT as an essential element of public transport and provide a safe NMT infrastructure, and
- Allocate adequate and sustainable funding for the development and promotion of NMT. The document also states that non-motorised transport will be provided on the basis of a number of principles including the need to improve the quality of life, energy conservation and safety. The policy also recognises the main components of non-motorised transport as animal-drawn transport, cycling and walking.

#### 3.4.5 National Land Transport Act 5 of 2009 (NLTA)

The NLTA provides that the Minister of Transport must facilitate the increased use of public transport and, in taking measures relating to public transport, must promote the safety of passengers, promote a strategic

and integrated approach to the provision of public transport and promote the efficient use of energy resources and limit adverse environmental impacts in relation to land transport<sup>3</sup>. Section 36 provides that every municipality must produce an Integrated Transport Plan (ITP). In doing so they must comply with the Minimum Requirements for Integrated Transport Plans for which require the larger municipalities to produce a Comprehensive Integrated Transport Plan (CITP) including a Transport Needs Assessment that must give due attention to NMT. These policies and legislative framework are all aligned as they have goal of having non-motorised transportation integrated with public transportation, also, having non-motorized transportation taken as a mode of transport that can be used daily.

#### 4 STUDY AREA

City of Johannesburg is the heart of the economy in the Republic of South Africa affording many different kinds of opportunities such as education, jobs, businesses etc., to many South Africans and international citizens. The city is made up of 7 regions and consists of 130 wards. Johannesburg is a divided city: the poor mostly live in the southern suburbs or on the peripheries of the far north, and the middle- and upper class live largely in the suburbs of the central and north (Smith, 2012). Around 20% of the city lives in abject poverty in informal settlements that lack proper roads, electricity, or any other kind of direct municipal service. Another 40% live in inadequate housing with insufficient municipal housing.

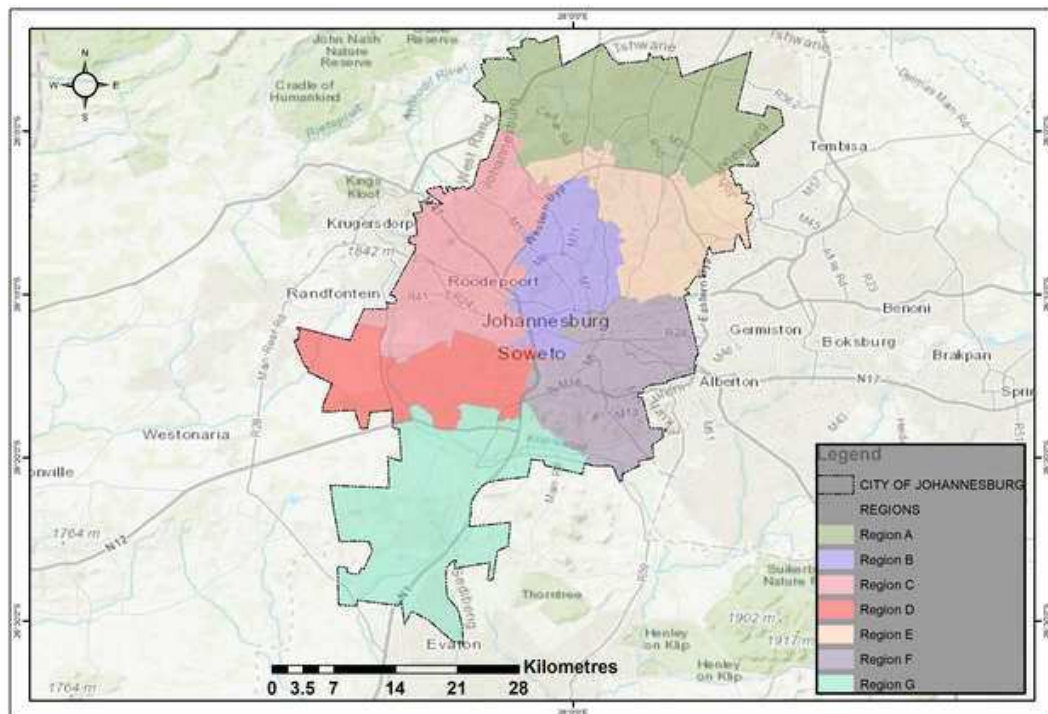


Figure 2: City of Johannesburg Map [Source: Authors, 2022]

Region A, B, C, D, E, F have the development of non-motorized transportation infrastructure such as cycling lanes with pedestrian side walks. Regions A, B, E, F, have the provision of innovative public transport, specifically, Gautrain and Gaibus system services and all regions across the city have the provision of Rea Vaya system, however, it does not service all locations and there is need for extensions. The City of Johannesburg innovative public transportation system is spread well across as in the northern areas there is dominance of Gaibus system and in the southern areas there is availability of Rea Vaya system, which however in time, there will be equivalent spread of both systems. Further, in the centre, there is availability of both system.

#### 5 METHODOLOGY

A mixed method research design was adopted where qualitative data and spatial data analysis was used. Various research instruments were employed in the study. Ten interviews were carried out with officials from different departments, including the Johannesburg Road Agency, Department of Transport, Gautrain and BRT officials and Metropolitan Municipalities transport planners/ They assisted in providing insights for

the study about the possibility of integrating non-motorised transportation and innovative public transportation as well as the different public transport modes (bus and train) in general. Accordingly, commuters were also interviewed to understand the commuter patterns and if there are any commuters who cycle to connect to innovative public transportation. 40 different daily commuters were interviewed who may have different experiences taking place daily. Purposive sampling was adopted as it was necessary to conduct interviews with informed officials and commuters. ArcGIS assisted with creating Gautrain rail tracks and Gaubus routes and stations; BRT route maps were showing locations serviced; Cycling lanes network patterns, together with physical integration of the innovative public transportation modes. BRT data (shapefiles), Gautrain data (shapefiles), Cycling lanes data (shapefiles), interviews, observations and documented studies relating to this study were the sources of data. Experimental analysis was conducted to understand the network patterns of NMT and innovative PT to identify possible areas of spatial integration. Further, content analysis was employed to review previous documented studies. Secondary data used was obtained from larger data base such as Scopus, Science direct, Sage and Google scholar.

## 6 FINDINGS

The development of non-motorized public transportation and innovative public transportation in the City of Johannesburg Metropolitan Municipality exist and the spatial integration between NMT and innovative PT in some locations is evident to indicate that the transport planners, urban planners and other stakeholders have been working on implementing integrating all transportation systems and modes to create efficient commuting across the city. However, not all aspects of cycling were addressed correctly to promote the use of cycling as a mode of transportation. The designed cycling lanes that currently exists, most individuals perceive them to be created for recreational purpose but not promoting a holistic transportation system. The lack of awareness campaign is one of the critical factors in regards to this matter. Consequently, most commuters indicated that the designed cycling lanes some of them do lead to public transportation modes stations/ hubs, however, there are no cycling parking lots next to the stations, this psychologically indicate that you can not use a bicycle to connect to public transportation. Further, it was indicated that cycling around the CBD its awkward and dangerous as there is too much traffic of motor vehicles on the roads.

Cycling across the City of Johannesburg is not commonly used as a mode of transportation and only 2% use it as transportation and not for trips more than 15km. It has be noted that most of the cycling that takes place across the city (i) it is for entertainment purposes such as events, (ii) cycling clubs, (iii) keeping fit as mode of exercise, which this mostly happen on weekends and after working hours. Officials indicated that the development of cycling lanes is part of a strategy to integrate public transportation and non-motorised transportation, however, city residents are not used to cycling or encouraged to cycle.



Figure 3: NMT and MT spatial integration around the CBD [Source: Authors, 2022]

The above figure 3 indicates Park station in the City of Johannesburg where there is feasible spatial integration of NMT and innovative public transportation and other areas within the CBD. The first image indicates the cycling lanes that are developed around the CBD for cycling. The second image indicates the BRT Rea Vaya station that is next to Gautrain and Gaubus station, with also development of cycling lanes just next to the innovative public transportation stations. Further, the third image shows the cycling lanes in the other areas around the CBD, however, the image indicates the current situation of the developed cycling lanes that are found around the CBD which indicates that the lack of usage in cycling lanes motorists turn

these cycling lanes into side parking for motor vehicles and this has occurred for a number of years after immediate development of the cycling lanes.



Figure 4: COJ south townships NMT and MT spatial integration [Source: Authors, 2022]

The above figure 4 indicates the development of non-motorised transportation infrastructure and innovative public transportation system in the southern township areas of the City of Johannesburg. The first image indicate the cycling lanes that are currently developed and there are more developments of cycling lanes taking place. The second image indicate the spatial integration of non-motorized transportation infrastructure with Rea Vaya system. The third image, indicates the pedestrian side-walks that have been developed together with cycling lanes. Rea Vaya system is the only innovative public transportation developed in the southern areas of the city. Therefore, the spatial integration that currently exists in some areas are between non-motorized transportation and Rea Vaya system. The development of cycling lanes in these areas are mostly found in the main roads and mostly they do not feed inside some areas from the neighbourhood to the Rea Vaya station. Further, there is still lack of cycling parking next to Rea Vaya stations

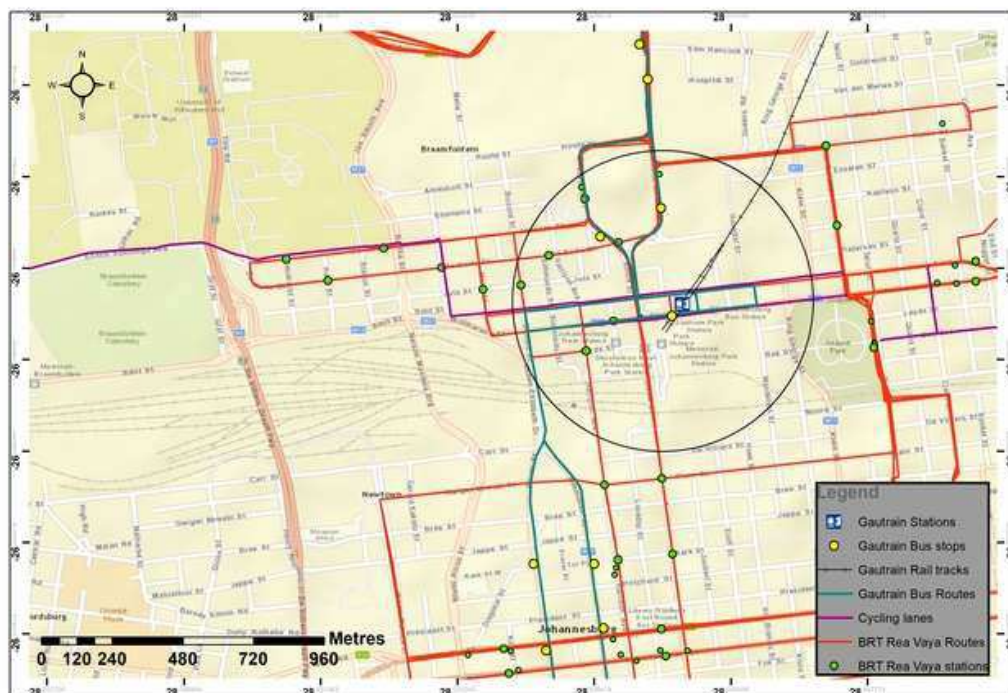


Figure 5: COJ central NMT and MT spatial integration map [Source: Authors, 2022]

Park station and the nearby areas have the visibility of being highly serviced by Gautrain/Gaubus system, Rea Vaya system and provision of cycling lanes as well as the pedestrian sidewalks. Park station according to figure 5 in the above map serve as a spine of non-motorized transportation and innovative public transportation as pedestrian side-walk, cycling lanes, gautrain/gaubus station and Rea Vaya are less than 100 metres apart from each other. This area is well serviced, and can allow for integrated transportation network system. Since southern areas of the City of Johannesburg are only serviced by Rea Vaya system and northern areas of the City of Johannesburg are serviced by Gaubus, if there is institutional integration between Gautrain system and Rea Vaya system, this can allow seamless travelling across the city through switch

inbetween in Park station and near stations that are highlighted on the map. Further, with improvements in the development of cycling, there could be smooth travelling created feeding innovative public transportation systems. Commuters will not be forced to walk far or travel far around the CBD to board a certain mode of innovative public transportation but can have an alternative and later switch in-between.

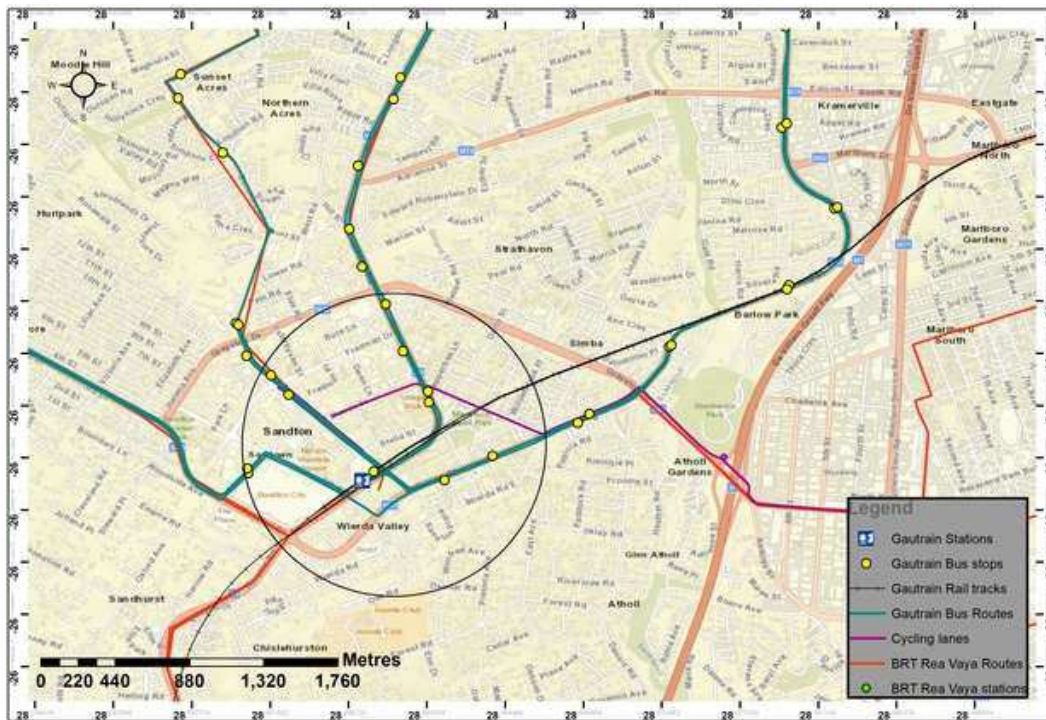


Figure 6: COJ north NMT and MT spatial integration map [Source: Authors, 2022]

The above figure 6 indicates NMT and innovative public transportation in the northern areas of the City of Johannesburg. Northern areas of the city are dominated by the use of Gaubus services, with the visibility of Rea Vaya system also servicing the area. Consequently, There is visibility of the development of cycling lanes in the northern areas of the city with assurity of the development of pedestrian sidewalks. In different areas, there is spatial integration of NMT and innovative public transportation as there are cycling lanes that lead to innovative public transportation stations as there cycling lanes passing through Sandton Gautrain stations and Gaubus stations from different neighbourhoods with Rea Vaya routes joining Gaubus route network. Further, increasing of cycling lanes to other neighbourhoods can assist commuters to cycle to the nearest locations of Gaubus station and Rea Vaya stations. Consequently, the highlighted areas indicate a good spatial integration of non-motorized transportation and innovative public transportation which could be a starting point to focus on development of recognized points of integrated network for commuting.

## 7 DISCUSSIONS

The development infrastucture of cycling lanes have not fulfilled the prime objective across the City of Johannesburg. In areas were the development of cycling lanes are developed together with pedestian side walks, they are perceived as sidewalks and are not used much for cycling. In areas that the cycling lanes are developed next to the roads, they are percieved as side parking. Currently, there are more developemnt of cycling lanes that are taking place especially the cycling lanes next to pedestrian sidewalks. This raises questions of why more cycling lanes are developed if they are not used, is it maybe hope or is it maybe for rolling out projects because this does not improve transporation at all. Most of these cycling lanes that are developed, they are strategically developed to feed public transportation stations and most of them are found in the main roads. The challenge is the lack of awareness campaign of the usage of these cycling lanes, they are just developed and assumable that the public will use them and there are no promotions done to attract people to start using them and create a stigma of cycling to everywhere especially trips that are not very long.

A possibility of integration for NMT and innovative public transportation is visible and is possible. (i) If the city can teach people and make them aware of the need to cycle and why cycling lanes are developed, (ii)



development of bicycle parking next to innovative public transportation stations with good security system, as there are many public open spaces and public institutions close to innovative public transportation that can be used for bicycle parking lots, (iii) for a desired outcome for these cycling lanes to be used efficiently and promote cycling, the city needs to financially support the innovative public transportation with bicycles provision that can be used by daily commuters in a sense of cheap rentals and free provision to old users. On some instances more money should be used for a certain goal to be achieved, already development of NMT and innovative public transportation infrastructure has been made and developed. This could encourage and attract more usage of both innovative public transportation and NMT, and if there is more usage of cycling more people buy into the tradition of cycling and the entire city could be transformed in this aspect as accessibility to travelling becomes more convenient, and this could reduce some of the challenges that the city is facing in-regards to traffic congestions and other related challenges associated with private motor vehicles.

The national policies and legislative frameworks are aligned with supporting the spatial integration of the NMT and innovative public transportation, and the developments of both innovative public transportation and NMT across the city has shown practical existence from the point of having different innovative public transportation strategically developed close to one another, to cycling lanes developed next to pedestrian walks connecting to innovative public transportation. However, all this positive development and initiatives of cycling lanes are currently not working for a daily usage, as this infrastructure knows cycling when people are cycling for fitness and entertainment purposes other than that they do not serve their full potential. Therefore, a need for policies and legislative frameworks that align to the current situation on the ground with the under used cycling lanes and which are deteriorating from being used by motor vehicles, consequently, how best can the city promote the usage of cycling and the linkage of cycling with public transport. A knowledge gap exists in how do the city's residents effectively use cycling as a form of transportation, and consequently use bicycles to connect to innovative public transportation. Further, how can non-motorized transportation be integrated with innovative public transportation.

## 8 NMT AND INNOVATIVE PT MODEL

Bicycles are eco-friendly and are very cheap together with their maintenance. For this model to work in the City of Johannesburg, there is a need for usage of bicycles and for this to be a possibility, there should be rented bicycles by service providers, and service providers could join with the city management to ensure the possibility of bicycles availability.

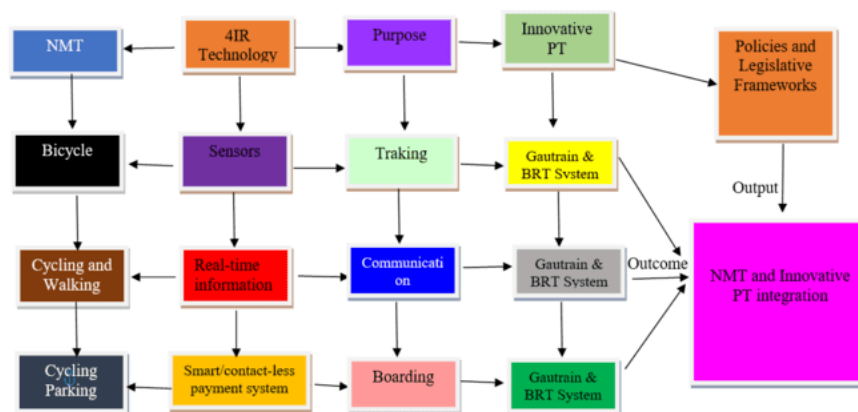


Figure 7: Passenger cyclist model (PCM) [Source: Authors, 2022]

City of Johannesburg has proper functioning innovative public transportation and developed NMT infrastructure which however needs to be fully developed, specifically, creating bicycle parking within the innovative PT stations. The above figure is a proposed model to integrate NMT and innovative public transportation across the city. Development of bicycle parking in or next to innovative public transport need to function consequently with innovative PT. 4IR Technologies acts as the central point to integrate NMT and Innovative PT. There is still a gap in identifying ways on how the 4IR technologies could be leveraged in NMT, and this model could be one of the first models to provide an idea that can work for both NMT and Innovative PT. Technological equipment could be installed in the service providers bicycles to be able to track bicycles for monitoring and management. This tech used in the bicycles can be linked in the smart

phone app to detect movement speed of bicycle and the mode that is to be boarded by a commuter. The function of the model is as follow:

(i) Sensors are critical for tracking bicycles, train and bus. A mobile smart phone could be developed that will include BRT system, Gautrain system and Bicycles for commuters who will be cycling to connect to innovative PT stations. A commuter who cycles to the station can be able to be informed in real-time how long will it take to get to the station and board a bus or train that a commuter is interested in taking. The sensors installed in the bicycles can have indicators (a) green indicator which will show that the cyclist is still on track to get in time to the station to board the intended bus or train, (b) yellow indicator which will indicate that the cyclist is behind and need to cycle faster to be able to reach the station on time, (c) red indicator which will indicate that the cyclist is very behind and will not be able to reach to the station to be able to take the intended bus unless the cyclist cycle quick and the indicator turns green.

(ii) Real-time information can be distributed through the mobile app which will be beneficial for commuters walking and cycling to notify commuters to know how far the bus or train is and the time it will take to reach the station of interest and other stations by bus or train with the current conditions at that particular moment e.g if there is traffic congestion or a particular certain mode is travelling fast and can reach the station than expected. The information in real-time can also assist commuters who switch inbetween modes (Rea Vaya system to Gautrain system or from Gautrain system to Rea Vaya system) to complete a certain trip to be able to plan their journeys properly.

(iii) Smart cards/contact less payment can be integrated for a Gautrain system and a Rea Vaya system which will allow seamless travelling with a certain agreement of profit sharing between the two systems if there were switch in-betweens made by commuters. Accordingly, the use of the integrated smart card/contactless for Gautrain system and Rea Vaya system for fare payment could be used to pay or gain access for bicycle parking in the relevant stations. Benefits provided by service providers such as free parking to monthly innovative public transport users could be provided at a more cheaper rate or free to attract more ridership and promote cycling in the city. Further, service providers could have bicycles that are rented to commuters and commuters to gain first preference of access to such benefits are registered commuters with integrated smart card of Gautrain system and Rea Vaya system. Further, contactless payment through smart phones are an advantage as they provide alternative for payment if an individual is not carrying a smart card and they bring services into one platform for example information dissemination and payment method could be all setup in one app for Gautrain system, Rea Vaya system and NMT.

(iv) Policies and legislative frameworks need to stress the importatnce of integrated public transportation system in the city and the country as a whole. These documents should be strengthened and support the use of NMT to create sustainable transportation. There current developed policies and legislative frameworks are not positively impacting NMT on the ground as the city is currently struggling to provide both a working system for NMT and a working system for integrating different public transportation systems. There is a need for policies and legislative frameworks to adress the connection of NMT, Rea Vaya system and NMT to be integrated as they promote sustainable development and are eco-friendly as the Rea Vaya system and Gautrain system ensure that carbon emissions are low as possible, and they reduce city's CO2 emmision. With the introduction of 4IR technologies, policies and legislative frameworks need to indicate the gap that could be solve which have existed for years and for the first time in the city's transportaion system integration could be possible.

Passenger cyclist model is intended to connect Innovative PT and NMT through technological innovations that are afforded in the 21st century to ensure that mobility in cities and urban areas is sustainable. This is the first model of its kind that include technology to integrate NMT and MT, it is feasible and could be implemented in many cities working towards affording sustainable public transportation. Providing a sustainable transportation systems require different strategies from city regulators and service providers. Having subsidize bicycles by the service providers which are rented cheap at a rate that is less and even lesser when having a smart card would attract more coummuters to cycle, and such alternative of having availability of bicycles could attract motorists as well as most people do not like to walk to station as it is time consuming. Using technological innovations that could improve effeciency in innovative public transport by ensuring effecient movement of buses and trains being frequent in all stations as per demand improves ridership. In general, people are attracted to systems that are well tailored and everything is set to

one platform. Hence, integrating Gautrain system, Rea Vaya system and bicycles as well as walking can provide a sense of convenience, and ideal way of daily travelling for commuters and even better with technology involved as people enjoy the use of technological innovations.

## 9 CONCLUSION

The paper has revealed the existence of availability of infrastructure for non-motorised transportation and the development of innovative public transportation in the City of Johannesburg, and further assess the points of areas that are serviced by both non-motorised transportation and innovative public transportation were there could be possible integration. Most noticeable in this paper, there is insufficient cycling, no bicycle parking stations, no recognised integration between innovative public transportation and non-motorized transportation, commuters either walk or drive private vehicles to Rea Vaya or Gautrain stations but do not cycle. Further, only few people make trips by bicycles as a form of transportation and trips made are not over 15 km or 10 km. However, there is a possibility of having integrated transport network system of non-motorised transportation and innovative public transportation as the network patterns of pedestrian side-walks and cycling lanes across some areas in the city connect with Gautrain/ Gaubus stations and Rea Vaya stations.

The study recommends the development of bicycle parking stations next to innovative public transportation stations to encourage the usage of cycling, and institutional integration of innovative public transportation to create swift transportation for commuters. Consequently, implementation of passenger cyclist model that will enhance the mobility across the City of Johannesburg and the country as a whole. Further, development of more non-motorized transportation policies and legislative frameworks that will support and encourage non-motorized transportation and integration of non-motorized transportation and innovative transportation. Further, financial aid support by the government to provide bicycles to commuters through innovative public transportation to encourage cycling and more usage of innovative public transportation could be an advantage.

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