DIGITISATION OF THE REGULATED MINIBUS TAXI NETWORK: A CASE FOR GAUTENG PROVINCE

S MHLANGA[1*], K MURONGA[1] and M NDAMASE[2]**

[1]CSIR Smart Mobility, Transport Systems and Operations, PO Box 395, Pretoria 0001
*Tel: 012 841 3169; Email: smhlanga1@csir.co.za
**Tel: 012 841 2337; Email: kmuronga@csir.co.za
[2]Gauteng Dept of Roads and Transport, 45 Commissioner Street, Johannesburg 2000
Tel: 011 355 7332; Email: malebo.ndamase@gauteng.gov.za

ABSTRACT

Gauteng Minibus Taxi industry and Government have identified the need to eradicate violence as well as improve public records keeping to aide better regulatory outcomes. The significance of paper represents a contribution to transport planning and MBT regulation in resolving data redundancy.

There exists no reliable spatial dataset of MBT routes in Gauteng. Currently, *NLTA Regulations* does not prescribe physical route mapping as a requirement to the license application process but makes provision for recording detailed route description and physical verification of routes.

The paper methodology is descriptive in nature and illustrates techniques and processes undertaken to develop a geo-spatial database of routes with defined network operational attributes for Gauteng Transport Authorities. Catalogue statistics includes route lengths, hypothesised variation in route navigation, regional and provincial network (km), Origin and Destination names.

Paper concludes that GIS routes baseline requires continuous update to effectively enhance understanding of MBT industry operations for public transport network integration and planning purposes.

Keywords: Transport planning, Minibus Taxi, public transport, Regulation, Network planning, Sustainable Transport, GIS.

1. INTRODUCTION

It has been over decade since implementation of the *2007 Public Transport Strategy (PTS)* and *National Land Transport Act and Regulations No 5 of 2009 (NLTA / NLTR)* - national policies and legislation that offered South Africa, a foundation to progress accelerated modal upgrade of public transport fleet, services including associated infrastructure development (NDOT, 2009) (NDoT, 2007) (NDoT, 2007).

The World Bank (WB), United Nations (UN) and RSA government have all identified improving MBT market, its regulation and reliability of regulatory instruments to aide healthier governance. Such prioritization can represent a critical pillar to improving healthy on-road competition, sustainable transport businesses, advancing integration, transformation and modernization of existing road based public transport operations and systems.

Historically, MBT industry had disdained network and infrastructure planning approaches adopted arguing a) lack of participation, b) inaccuracy of information on routes and market participation and c) subsequent government value chain interventions; thus, resulting in difficulties implementing policy reform initiatives including Integrated Public Transport Network (IPTN) and Bus Rapid Transit (BRT) systems.

1.1 Overview of the Paper

In Gauteng, the provincial government in its 2013, *25 years Integrated Transport Master Plan (ITMP25)* had committed through establishment of the Transport Authority, to support and facilitate optimized management of public transportation system whilst improving its quality by implementing sustainable mobility initiatives (GDRT, 2013). To this effect, the strategy had identified the case for a Transport Authority to manage regions with a diversity of land use and multimodal transport system desire.

Pertinent to this paper are the top 5 key short-term development initiative and focus areas, which included Taxi industry transformation (GDRT, 2012). The initiative was geared towards promoting a viable, sustainable, and healthy development of urban transport as critical building blocks. To demonstrate industry support, Gauteng authorities in July 2016 Taxi Summit adopted a Joint Declaration between government & provincial taxi industry structures to collaborate in undertaking planning for MBT and wider public transport (GDRT, 2016).

1.2 Background

Availability of a comprehensive set of quality information is critical to building a solid business case to understanding macro and micro operational aspects, potential economic contribution and sustainability trajectory of MBT industry and its associated value chain.

In RSA, application and registration of public transport (including minibus taxi) routes and operating license is a concurrently legislated responsibility between three spheres of government. National Land Transport Information System (NLTIS) is a public transport register mainly used to manage the applications process for, including upliftment of operating licenses. NLTIS essentially integrates registration information from Provincial Registrars (PR), Operating License Administration System (OLAS), Registration Administration System (RAS) as well as the Provincial Bus Subsidy Management Systems (SUMS).

1.3 Problem Statement

The regulation of minibus taxi operations in South Africa has presented challenges for transport authorities seeking to ensure improved and better management of broader public transport system outcomes. Much of this inability is historic in nature as documented by researchers (Moolman, 1998; Oosthuizen & Mhlambi, 2002; Schalekamp, Behrens & Wilkinson, 2010; Schalekamp & Behrens, 2013) and primarily relates to issues significantly attributable to outdated manual data management practices; statements of undue influence, forgery, fraud etc. in the operating license application process. MBT industry had derided, a) accuracy of existing data on routes due to NLTIS system crashes that resulted in loss of critical industry data, b) proliferation of fraudulently registered joint-ventures and route duplication. These issues were identified as significant impediments to industry transformation and regulation aspirations (GDRT, 2016).

There exists no reliable spatial dataset of routes records. Currently, NLTA Regulations does not prescribe route mapping as a requirement but detailed route description. This practice entails that in-loco (physical) route verification of pending new or amendments to routes does not utilize GPS enabled technology. RAS records routes are typically characterized by detailed descriptions of a route from origin point to destination including landmarks that often-become redundant overtime.

In seeking to improve the quality of existing RAS records a project was developed to digitize existing records into functional GIS compatible database to support enhanced spatial visualization, transport planning and regulation.

1.4 Objectives of the Paper

The objectives of this paper is to a) describe processes to develop and produce a GIS based database b) illustrate database capability in enhancing spatial visualisation and annotation of MBT industry in Gauteng.

2. METHODOLODY: DATA COLLATION AND STATISTICAL DESCRIPTION

The process to digitize official routes allocated to MBT associations; from paper (PDF) to electronic data format i.e. shapefiles (SHP), KML, KMZ etc. represented the preliminary foundation to transforming route information from paper to electronic. These activities entailed collecting, collating and investigating available information from possible available data sources including municipal Current Public Transport Record (CPTR's), District Municipal Integrated Transport Plans (DITP), Household Travel Surveys (HTS) and Registration Administration System (RAS).

Overall, RAS had higher recorded number of associations in Gauteng. Conversely, in relation to routes, with the exception of Sedibeng (SED) and West Rand (WR), Johannesburg's Transport Information Register (TIR) recorded a significantly larger number of routes compared to RAS however, total associations in RAS substantially exceeded TIR. Similarly, TSH's CPTR and WR's DITP had higher number of routes whereas RAS contained high records on associations.

Table 1 illustrates comparison of datasets, evidently there was dispersed varying total counts and mean values between sources whilst exhibiting higher standard deviation (σ) between routes datasets. The observed variances were extremely substantial and did not enable adequate benchmarking of industry network. Standardization between the datasets was challenging to achieve given varying sources, base years and approaches i.e. data collection objectives and reporting periods including methodological applications.

Nonetheless, data collation outcome established significant inconsistencies in seeking to benchmark network configuration from existing sources.

Table 1: Data collation of MBT associations and routes

Region	Source	Total routes	Source	Total Associations
Johannesburg	RAS (2016)	1164	RAS (2016)	79
	SITPF (2014)	1013	SITPF (2014)	32
	TIR (2013)	3765	TIR (2013)	33
	HHTS 2013	1932		
Tshwane	RAS (2016)	361	RAS (2016)	39
	CPTR (2013-17)	1070	CPTR (2013-17)	17
	GDRT (2016)	442	GDRT (2016	33
West Rand	RAS	236	RAS	19
	IPTN (2013)	65		
	DITP (2011)	199		
Ekurhuleni	CPTR (2006)	856	CPTR (2006)	9
	RAS 2016	645	RAS 2016	30
	DGD 2016	645	CITP (2013-2017)	24
	HHTS 2013	981	GDRT (2016)	30
Sedibeng	RAS	249	RAS	16
	IPTN (2013)	164	DITP (2008-13)	19
	DITP (2008-13)	232	CPTR (2009)	17
	CPTR (2009)	232		

Table 2: Gauteng RAS Descriptive Statistics

Description	***Number of Associations***	***Number of Members***	***Number of Routes***	***Total Route Length (km)***
Mean	35,0	9441,6	587,2	56964,6
Standard Error	9,9	2818,7	173,7	19917,2
Median	31,0	11402,0	536,0	50003,0
Standard Deviation	22,2	6302,8	388,4	44536,2
Sample Variance	494,0	39725776,3	150870,7	1983474590
Range	54	13261	951	103825
Minimum	17	2515	222	16513
Maximum	71	15776	1173	120338,0
Sum	175	47208	2936	284823,0
Region Count	5	5	5	5,0

Further, regression of RAS routes number against members and associations identified presence of positive relationships for both dependent variables; the former was insignificant whereas the latter relationship was significant $R^2 = 0.89$ and p-value of 0.015 at a confidence level of 95%. At this estimate, RAS was considered reliable source to benchmark MBT routes operating in Gauteng.

Next, this paper focuses on the outcome of the conversion process and introduces a geographic annotation of the industry as documented in RAS.

3. DIGITIZATION APPROACH

Official MBT association route records were gathered in the form of text descriptions of the physical routes, often containing outdated common landmarks, street names etc., and factors susceptible to change with development in land use and traffic flow. Information relating to routes for each registered MBT association in Gauteng was digitized using the process illustrated in the following figure using Google Maps and other GIS tools.

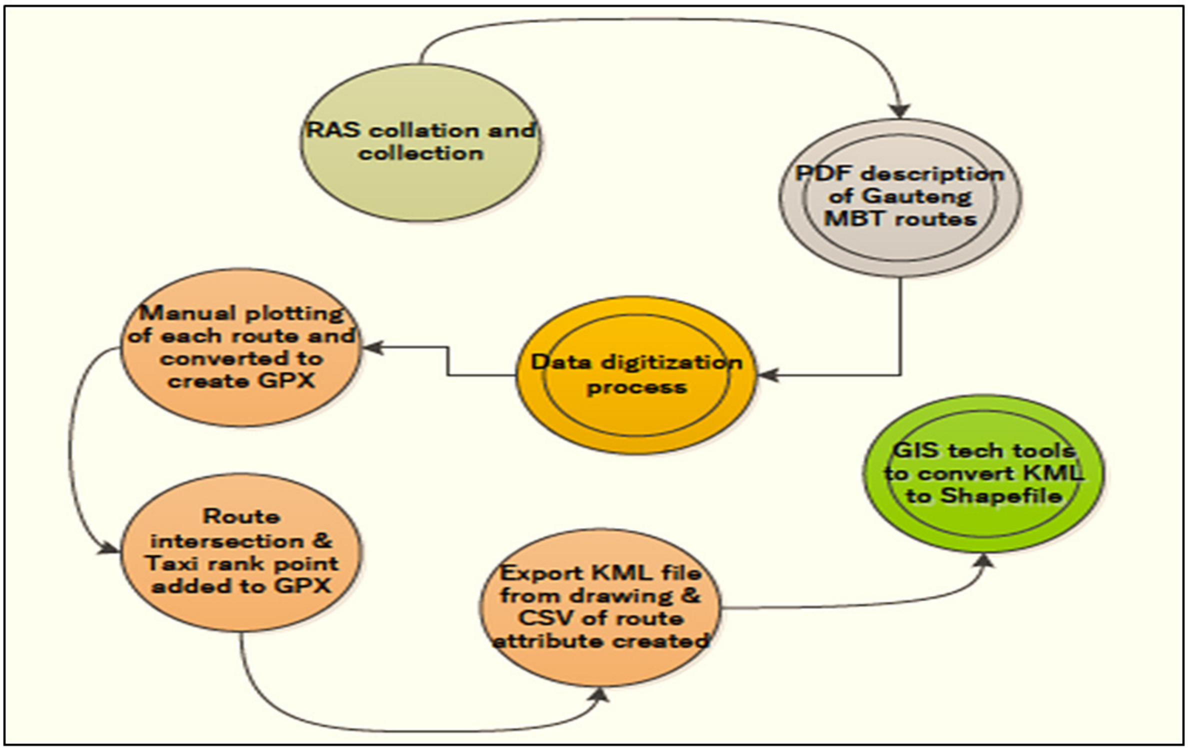

Figure 1: Process flow from collation, digitization to conversion

PDF conversion process was difficult to execute and characterized by manual, monotonous drawing of routes on a canvass and involved, to an extent, estimation of possible route navigation and alignment of line segments. In some instances, a single route could reproduce more than three alternative/possible variations to a route depending on perceived as well as known changes in traffic flow and other parameters. The methodology to digitize routes is illustrated graphically in Figure 1.

In specific instances, some routes could not be practically plotted on a map. These routes were characterised by blank records on some recorded routes, including route descriptions that either did not exist or could not be followed using current mapping and traffic-flow tools. No assumptions or logic could be applied in attempting to digitise such routes and were subsequently excluded from the digitisation. However, due to complexities of plotting outdated street information to match current realities, digitisation process resulted in generation of a number of possible alternatives alignment for both forward and return trip of routes.

To achieve compatibility to GIS technology, a combination of open and licensed GIS technologies (ArcGIS and QGIS tools) tools were adopted to assist the conversion process of Google Earth's KML into Shapefile format; whilst retaining the information and interrogation structure of the original dataset.

4. DATABASE ARCHITECTURE AND DEVELOPMENT

The design of Minibus Routes System (MBRS) commenced with the development of a framework to standardize data relations and requirements, as well as understand and further identify possible relationships that could be derived from the digitized datasets. Domestic and international best practices of records-keeping to facilitate adequate public transport planning were adopted to benchmark design of MBRS architecture. The NLTA prescribes data formats and requirements for transport planning regulation purposes. Additionally, a common international format i.e. Google's General Transit Feed Specifications (GTFS) for public transportation schedules and associated geographic information was also incorporated into the structure of the data requirements for the MBTRS.

Database structure enabled cataloguing of datasets according to 'one to many relationship', i.e. within each table of attributes, a unique variable can produce various possible other relations and results that could be useful in analyzing and aggregating reporting of MBT industry statistics.

Illustratively, MBRS depicts a geo-coded (digitized) understanding of MBT routes in Gauteng as recorded in RAS. MBRS architecture is designed to adopt a less intricate structure and is split according to a) map data, b) routes data and c) output data. At a high level, MBRS is able to achieve the following dashboard functionalities:

- For every region, a user can generate a provincial summary in terms of total number of associations, members, and routes as total route lengths for each region.
- Detailed regional breakdown associations, number of members and registered routes
- Detailed regional breakdown of each route, i.e. origin and destination of each and every route digitised, route length etc.

The GIS data viewer platform facilitates user interface with MBRS to enable efficient interrogation of industry configuration. Typically, examination is executed through generation of queries on pre-selected variables including association name, route O-D names, etc. The screen shot (Figure 2) highlights a RAS route (forward and return trips) for the Poortjie Taxi Association (PTA) from Poortjie main taxi rank to Kloof Mine.

Information relating to specific association member details that include number of taxis registered and contained in the Operating License Administrative System (OLAS) was not part of the digitisation and such datasets are not incorporated into the current MBTRS. The capability to handle OLAS can be built into the database.

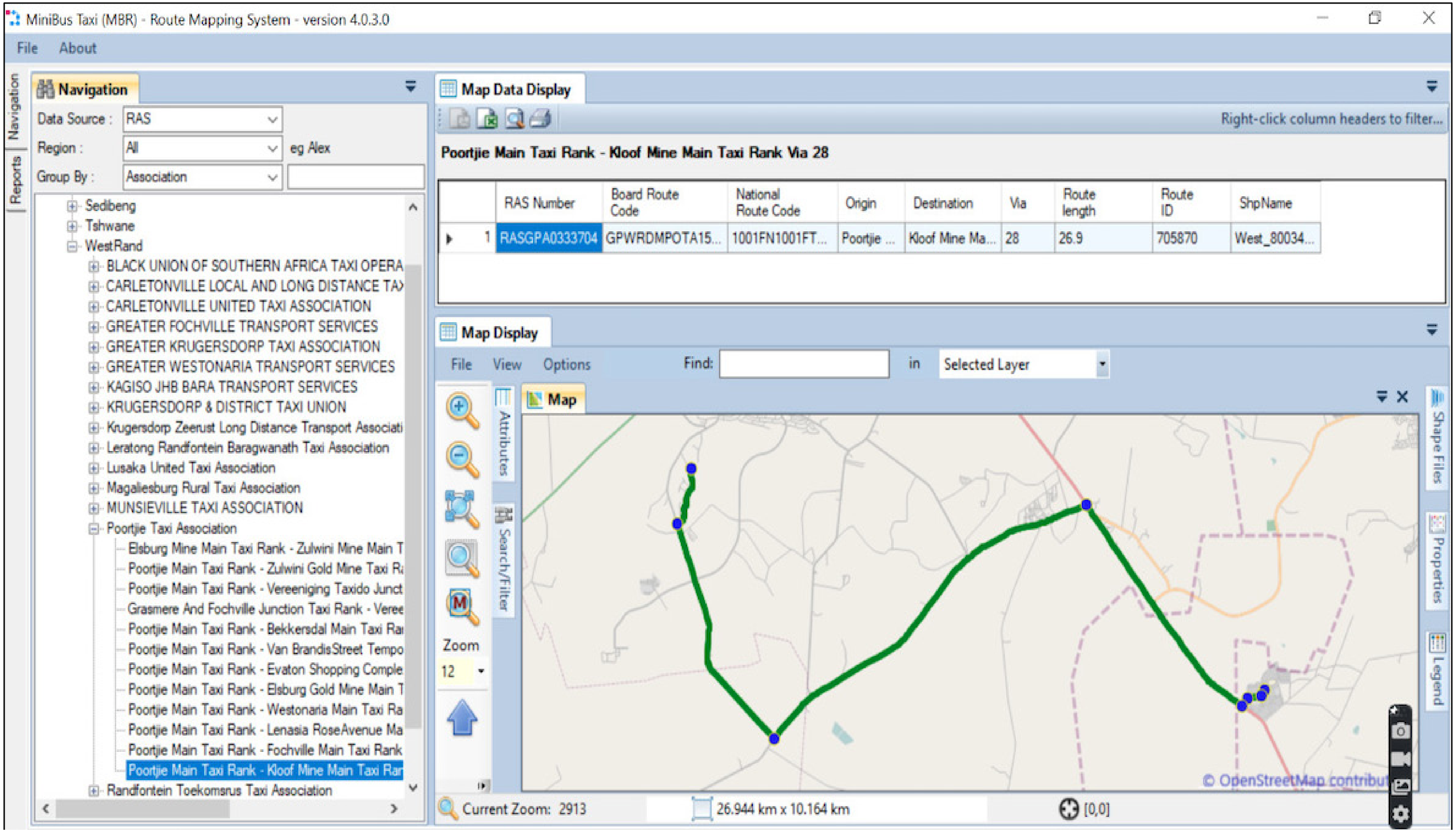

Figure 2: MBRS dashboard and navigation pane

5. DIGITIZATION RESULTS

The size of the Minibus Taxi Industry (MBT) regulated is illustrated in Figure 2: Gauteng Regional MBT. The Proportional distribution shows that Johannesburg and Ekurhuleni accounted for a significant percentage of registered routes operating in Gauteng, with a combined total of 64%, followed by Tshwane and the district regions accounting for the remaining network.

Regional ranking transforms when considering MBT industry statistics on market concentration. TSH had a higher density of participants at an estimated *registered member to routes ratio* of 29.4, followed by Ekurhuleni and Johannesburg at 15.5 and 12.4 respectively. SED and WR accounted for a similar ratio of 11.

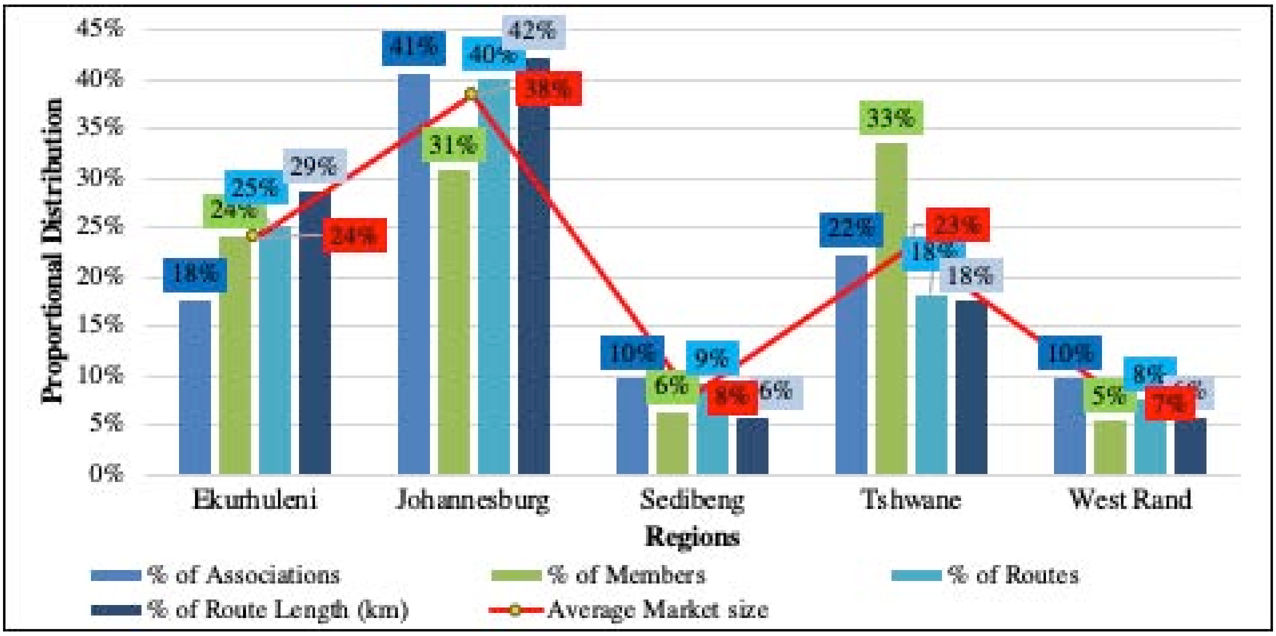

Figure 3: Proportional Regional Distribution of Gauteng MBT industry

A total of 284 823km of route length network is identified for all routes registered in RAS and of that, JHB had an estimated network length of 120 000km. Evidently from Figure 3, JHB ranked highest across all categories with the exception of registered members. EKH and TSH ranked 2nd and 3rd with an estimated network size of 81 000km and 50 000km respectively. SED and WR operated a similar network of 16 500km. Overall, the range of route lengths estimated were between 2km route to 1 1200km lengths. To enable disaggregated analysis, route distances can be clustered into categories for purposes of network cataloging as demonstrated in Figure 4.

Figure 4 geographically illustrates MBT industry network coverage and extent visualized in a GIS platform. In Figure 4, the study area, i.e. Gauteng boundary is enlarged to highlight network density of routes aggregated and denoting various line segments illustrated using differing color scheme

Disaggregation enabled appreciation of network extent according to a) routes operating within a municipality, b) between municipalities and c) interprovincial trips. Generally, medium-length routes were characterized by inter-municipal travel, particularly between metropolitan areas of Johannesburg, Ekurhuleni and Tshwane.

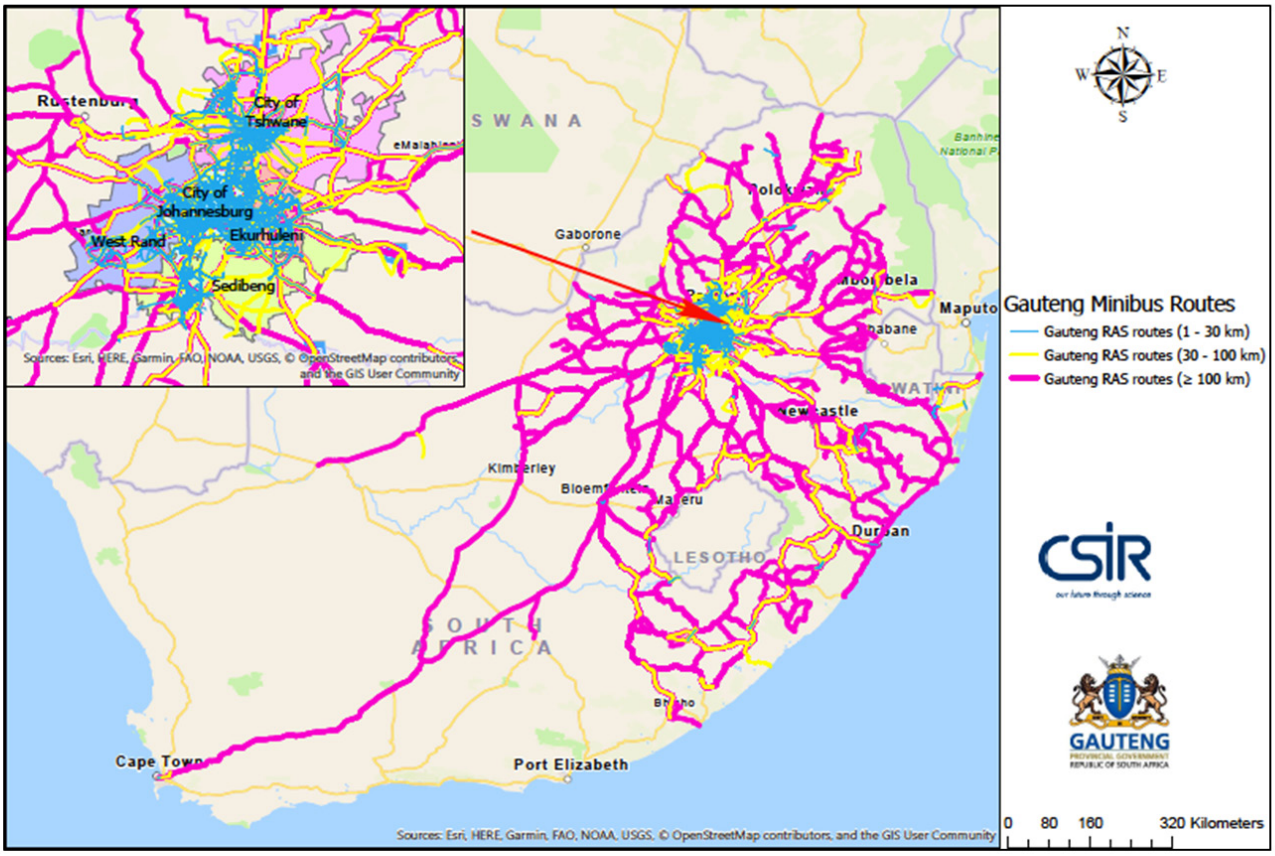

Figure 4: Gauteng RAS MBT Digitized Registered Routes

The MBT associations participating in long-distance services (18% of total market) operate an extensive interprovincial network with the highest association generating an aggregate route length statistic of 16 474km. Such a network would consist of routes between Johannesburg Park City to King William's Town, East London and Umtata (Eastern Cape) predominantly either via Ladysmith, Pietermaritzburg (KwaZulu-Natal); Bloemfontein, Heidelberg, Kokstad and Aliwal North (Free State); and Kimberley (Northern Cape).

6. CHALLENGES AND SHORTCOMINGS

One plausible explanation consistently advanced during the mapping project was challenges associated with a) changing of street names and b) outdated spatial landmarks contained in the original text route descriptions. These challenges entailed that mapping had to adopt some sort of logic with certain routes, and this resulted in the generation of additional possible alternative routes. As a result, digitisation outcome created 10-15% additional buffers on the geographically quantified network in each region to account for variations in traffic flow and landmark name.

Data collation of existing datasets used to prepare municipal statutory transport plans exposed inconsistencies outside of RAS, particularly in larger municipalities. In order to validate current operational status of routes as contained in RAS, physical in-loco verification processes, i.e. route audit and onboard surveys are desired. Network verification is critical to facilitate development of an appropriate basis for market and regulatory governance.

7. CONCLUSIONS

RAS digitization has progressed and permitted an improved understanding of existing MBT routes as shown in this paper. Moreover, benefits of geographic annotation and visualization of spatial supply network data and supply statistics have been demonstrated. Of fundamental importance however is the prospect of developing and integrating routes database supported by on-board survey information of operations. Such a platform will empower critical role players and authorities to *1) obtain better comprehension of MBT industry according to network types, services, infrastructure, signage, fares, frequency etc, 2) facilitate improved analysis of locality, condition, accessibility and security of industry stop offs', and 3) enable better transport planning i.e. network design and route determination*.

Considerably, development of Gauteng public transport GIS database can support government transport policy making processes and offer a concrete foundation to addressing sustainability problems associated with *a) route profitability determination, b) visual route and network verification c) inadequate research, planning and analysis, and d) industry regulation.*

8. RECOMMENDATIONS

Lastly, this paper suggests that continuous data collection exercises are paramount to facilitate optimized management of public transportation systems and quality improvement. Transport professionals, decision makers participating in urban affairs and organizations with a stake in urban mobility can find adequate insights and evidence to support public transport-oriented policies and other reform developmental initiatives.

9. REFERENCES

NDOT, 2009. *National Land Transport Act and Regulations. ,* PRETORIA: s.n.

NDoT, 2007. *Public Transport Action Plan – Phase 1 2007-2010: Catalytic Integrated Rapid Public Transport Network Projects. Pretoria,* Pretoria: NDOT.

NDoT, 2007. *Public Transport Strategy,* Pretoria: s.n.

GDRT, 2013. *Gauteng 25 years Integrated Transport Master Plan,* Johannesburg: www.gauteng.gov.za.

GDRT, 2012. *Gauteng 5-Year Gauteng Transport Implementation Plan,* Johannesburg:s.n.

GDRT, 2016. [Online] Available at:
https://www.gov.za/speeches/gauteng-government-host-provincial-taxi-summit-10-jun-2016-0000

Moolman, D, 1998. Taxi Violence in South Africa - The causative factors. Acta Criminologica. *Southern African Journal of Criminology,* 11(1):33-42.

Oosthuizen, S & Mhlambi, M, 2002. *The Road to Empowerment of Minibus Taxi Industry is full of pitfalls: Our experience and observations over many years.* Pretoria, SATC.

Schalekamp, H, Behrens, R & Wilkinson, P, 2010. *Regulating minibus-taxis: A critical review of progress and a possible way forward.* Pretoria, SATC, pp. Vol. 16, p. 19.

Schalekamp, H & Behrens, R, 2013. Engaging the paratransit sector in Cape Town on public transport reform: Progress, process and risks. *Research in Transportation Economics,* pp. 185-190.

Engineeringnews, 2017. [Online]
Available at: http://www.engineeringnews.co.za/article/appointment-of-a-service-provider-to-redesign-nltis-2017-09-15/rep_id:4136. Accessed 9 March 2019.