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Quality of Service Report:

Limpopo Province

2017/2018 Quarter 1

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List of Acronyms

CD	Call Duration
CSSR	Call Setup Success Ratio
DCR	Drop Call Ratio
GSM	Global System for Mobile Communications
IVR	Interactive Voice Response
WCDMA	Wideband Code Division Multiple Access
MOC	Mobile Originating Call
KPI	Key Performance Indicator

EXECUTIVE SUMMARY

The Authority conducted Quality of Service (QoS) measurements on the networks of the mobile operators: Cell C, MTN, Telkom and Vodacom. The measurements were performed to monitor performance of voice services offered by the mobile operators in Limpopo Province. The measurements were carried out in the period between 19 to 30 June 2017 and covered a total distance of over 2500 km.

The purpose of performing QoS measurements was to monitor and analyse the quality of mobile voice service as experienced by the end-user. The results are later benchmarked against the QoS standard set by the Authority. The measurements were conducted in areas and in circumstances where mobile voice service is likely to be accessed. These areas include major towns, townships, farm areas, rural areas, major road arteries, economic activity nodes and areas of previous complaints. The sampled areas include Thabazimbi, Lephalale, Ga-Seleka, Bakenberg and Aganang.

A vehicle equipped with TEMS Symphony measurement tool was used to collect data by driving through areas of interest. The two Key Performance Indicators (KPIs) used to assess QoS, are Retainability and Accessibility. The Drop Call Ratio (DCR) parameter is used to measure Retainability and Call Setup Success Ratio (CSSR) parameter measures Accessibility.

According to the End-User and Subscriber Service Charter regulations of 2016, DCR should be less than 3% and CSSR should be greater than 98%.

The results show that Telkom met the 98% CSSR target in Lephalale and Bakenberg but failed to meet the target in Thabazimbi, Ga-Seleka and Aganang. The CSSR for Cell C, MTN and Vodacom were less than 98% in all areas, thus these operators failed the Accessibility target in all the areas of interest.

MTN, Telkom and Vodacom met the Retainability target of below 3% in all target areas (Thabazimbi, Lephalale, Ga-Seleka Bakenberg and Aganang). Cell C failed to meet the target in Lephalale, but met the target in all other areas.

In terms of the overall results of the areas covered in Limpopo, all the operators' CSSR values were less than 98% and therefore they did not meet the Accessibility target. All operators' DCR was below 3%, thus they met the Retainability target.

1 Introduction

ICASA’s mission is to ensure that all South Africans have access to a wide range of high-quality communication services at affordable prices¹. The Authority ensures the quality of service through its Quality of Service (QoS) monitoring activities. The Authority conducted QoS monitoring of the GSM voice telephony service offered by Cell-C, MTN, Vodacom and Telkom within Limpopo Province of South Africa.

Limpopo Province is the northernmost province of South Africa and borders onto Mozambique, Zimbabwe and Botswana. Inland, it borders the Mpumalanga, Gauteng and North-West provinces. The province covers an area of 125 754km² and has a population of 5 779 090. It is the fifth-largest province in South Africa by both surface area and population. The capital is Polokwane. Other major cities and towns include Bela-Bela (Warmbad), Lephalale (Ellisras), Makhado (Louis Trichardt), Musina (Messina), Thabazimbi and Tzaneen².

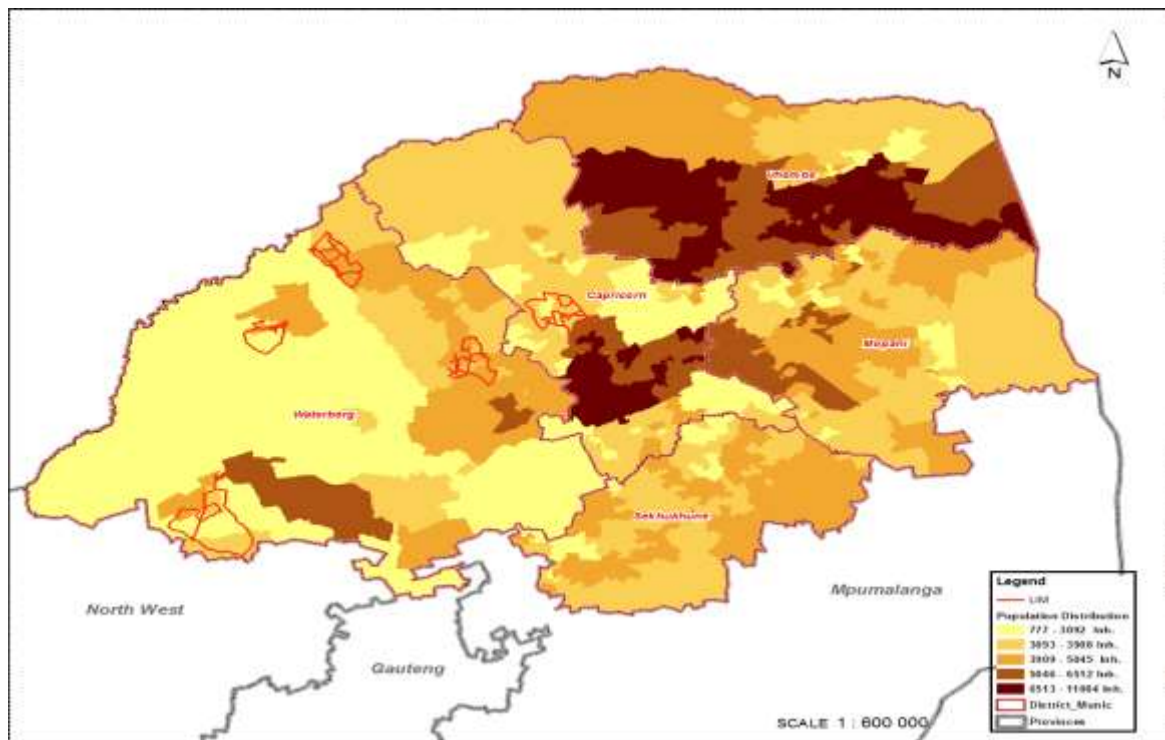


Figure 1: Limpopo Province Route Map

¹ ICASA Strategic Plan 2016/17-2021

² <http://www.localgovernment.co.za/provinces/view/5/Limpopo>

The QoS monitoring was conducted in the areas within Waterberg and Capricorn district municipalities. The selected areas include Thabazimbi, Lephalale, Ga-Seleka, Bakenberg and Aganang. The areas consist of major towns, townships, farm areas, rural areas, major road arteries, economic activity nodes and areas of previous complaints.

QoS is defined as the collective effect of service performance that determines the degree of satisfaction a user derives from a service. It provides an indication of what a customer experiences when using a mobile network and is evaluated in terms of Retainability and Accessibility parameters.

- a) Retainability is defined as the ability for a call to stay connected through to a normal call tear-down process, without abnormally disconnecting from the cell site that carries the call³. It is measured using Drop Call Ratio (DCR).
- b) Accessibility is defined as the percentage of the number of times a user is rejected due to the unavailability of system resources when attempting to place a call. It is measured using Call Setup Success Ratio (CSSR).

2 Methodology

A drive-test sampling methodology which provides a snapshot view of the mobile operator's quality of service was adopted. It provides a realistic picture of network performance from a user's point of view. The method adopted provides a snapshot of an operator's network performance selected routes and particular time of the day. It is therefore not a true representation of the mobile service provider's overall network performance.

2.1 Drive test equipment

The drive test was carried out using a test kit comprised of TEMS Symphony 7.7 software and hardware, eight Samsung Galaxy Note 4 (SM-N910F) mobile devices, a laptop computer and a TEMS Probe Controller 1.9. The mobile devices were configured to automatically select mobile network and radio access technology.

³ Annexure B.2 of ETSI EG 202 057-3

2.2 Route selection

Measurement routes were selected so that they would reflect end-user distribution at different geographical locations in areas where people live and use mobile phones (e.g. urban, suburban, major towns, rural towns, township, farm areas, highways, tourism areas and major roads).

The selected five areas in which the QoS measurements were conducted are within the district municipalities as indicated in Table 1 below:

Table 1: Selected routes and date

Test Type	District	Route Name	Dates
Accessibility and Retainability	Waterberg	Thabazimbi	19/06/2017 26/07/2017
		Lephalale	20/06/2017 27/06/2017
		Ga-Seleka	21/06/2017 28/06/2017
		Bakenberg	22 - 23/06/2017 27/06/2017
	Capricorn	Aganang	23/06/2017 30/06/2017

2.3 Equipment test setup and configuration

Table 2 below shows the test plan and configurations of the drive test equipment.

Table 2: Test plan and configurations

Configuration	Explanation
Antennas	Tests were carried out from a moving vehicle with roof-mounted antennas. The antennas were arranged in a well-defined fixed way. A minimum distance between antennas is

	<p>maintained to contain RF-influence on an acceptable level. The coupling loss between two mobile handsets was a minimum of 40.5 dB⁴.</p>
Band	<p>The bands tested for voice were GSM (900 and 1800 MHz) and WCDMA (900 and 2100 MHz).</p> <p>The bands scanned were GSM (900 and 1800 MHz) and WCDMA 2100 MHz</p>
Call Samples	<p>A minimum of 120 test samples per network operator were collected except in the areas where services were limited on most part of the drive test route. Test drives were planned to ensure, as far as practicable, that the results adequately reflect the QoS perceived by customers for the period under review.</p> <p>The drive test was designed to be representative of the population relative to the traffic of the network. Measurements were scheduled to reflect accurately the traffic variations over the hours of a day, and user's behavior⁵.</p>
Call Type and Window Call	<p>Long calls and short calls were used.</p> <p>Voice telephony was tested in the Mobile Originating Call (MOC) direction. The following call durations were used:</p> <ul style="list-style-type: none"> • CD1: 10 seconds for call setup testing; • CD2: 120 seconds for typical tests, default call duration; <p>Call Window: Call Duration + 30 seconds, (for the setup and release phases) + 30 seconds (for the minimum pause. Interval), for the default call duration this results in 180 seconds⁶.</p>
Equipment	<p>The equipment used for testing was the TEMS Symphony 7.7 equipped with Samsung Galaxy Note S4 (SM-N910F), PCTEL EXFlex Scanner and Dell Latitude with TEMS Probe Controller 1.9.2.</p>

⁴ Section 6.3 of ETSI TS 102 250-4 V.1.1.2 (2003-10)

⁵ Section 4.8 of ETSI EG 202 057-3 V1.1.1 (2005-04)

⁶ Section 4.2.1 of ETSI TS 102 250-5 V1.2.1 (2005-05)

KPI ⁷	The measurements focused on the following network parameters: (i) Dropped Call Ratio (DCR); (ii) Call Set-up Success Ratio (CSSR)
Log files	The log files for each test case were stored in different locations with different names. The log files were recorded per network operator.
Mobile terminal used	The test calls were terminated on each operator's test platform or IVR system.
Network tested	Cell-C, MTN, Vodacom and Telkom.
SIM cards	Test SIM cards provided by each operator were used during the drive test.
Vehicle used	A Toyota Hilux Double Cab van equipped with drive-test equipment was used. All the road traffic rules were observed during the drive test. The speed was maintained to an average of 60km/h in town and built-up areas, and an average of 100km/h on highways.

2.4 Statistical significance

The purpose of statistical analysis is to present the statistical accuracy of reported KPIs. This means that one can be "relatively sure" that the results represent the reality (true population mean) and that they did not occur by chance. Statistical theory provides tools to assess the statistical significance of measurement observations with a given sample count and standard deviation.

2.5 Measurement parameters and targets

2.5.1 Parameter targets

The Average Drop Call Ratio should be less than 3% over 6 months' period and Average Call Setup Success Ratio must be greater than 98% over six months' period as per the "End-User and Subscriber Service Charter Regulations of 2016".

⁷ End-User and Subscriber Service Charter Regulations of 2016

2.5.2 Drop-Call Ratio

Dropped Call Ratio (DCR) is the proportion of incoming and outgoing calls, which, once correctly established and therefore having been assigned a traffic channel, is dropped or interrupted prior to the deliberate completion by the user⁸.

The formula to calculate DCR is shown below:

$$\text{DCR} = \text{D/S} * 100$$

where D represents the number of dropped calls and S is the number of successful call attempts

2.5.3 The Call Setup Success Ratio

The Call Setup Success Ratio (CSSR) is the percentage of calls that are successfully set up as a percentage of the total call attempts⁹.

The formula to calculate CSSR is shown below:

$$\text{CSSR} = \text{Y/X} * 100$$

where Y represents the calls that are call established and X is the total number of call attempts.

⁸ End-User and Subscriber Service Charter Regulations of 2016

⁹ End-User and Subscriber Service Charter Regulations of 2016

3 Results and analysis

This section provides a summary of the mobile operator's performance results based on the drive test route in the following test areas: Thabazimbi, Lephalale, Ga-Seleka, Bakenberg and Aganang.

3.1 Accessibility and Retainability measurements

Table 3: Summary of results

Route Name	Operator	CSSR	DCR
Thabazimbi	Telkom	96.71%	0.27%
	Cell C	86.86%	1.18%
	Vodacom	95.90%	1.65%
	MTN	96.51%	2.27%
Lephalale	Telkom	98.01%	0.00%
	Cell C	95.64%	3.69%
	Vodacom	93.71%	0.70%
	MTN	93.50%	1.50%
Ga-Seleka	Telkom	95.83%	0.00%
	Cell C	92.91%	1.50%
	Vodacom	93.84%	1.65%
	MTN	96.29%	1.17%
Bakenberg	Telkom	98.31%	0.24%
	Cell C	96.95%	2.33%
	Vodacom	95.61%	2.06%
	MTN	95.83%	1.16%
Aganang	Telkom	96.76%	0.52%
	Cell C	92.41%	0.87%
	Vodacom	96.84%	1.86%
	MTN	91.77%	0.49%
Overall results for the above 5 areas	Telkom	97.07%	0.20%
	Cell C	92.89%	1.82%
	Vodacom	95.14%	1.64%
	MTN	94.92%	1.27%

Table 3 above shows voice call measurement results in each route and as an overall for all areas for all the operators. Detailed results are presented in the Appendix 5.

3.1.1 Call Setup Success Ratio (CSSR)

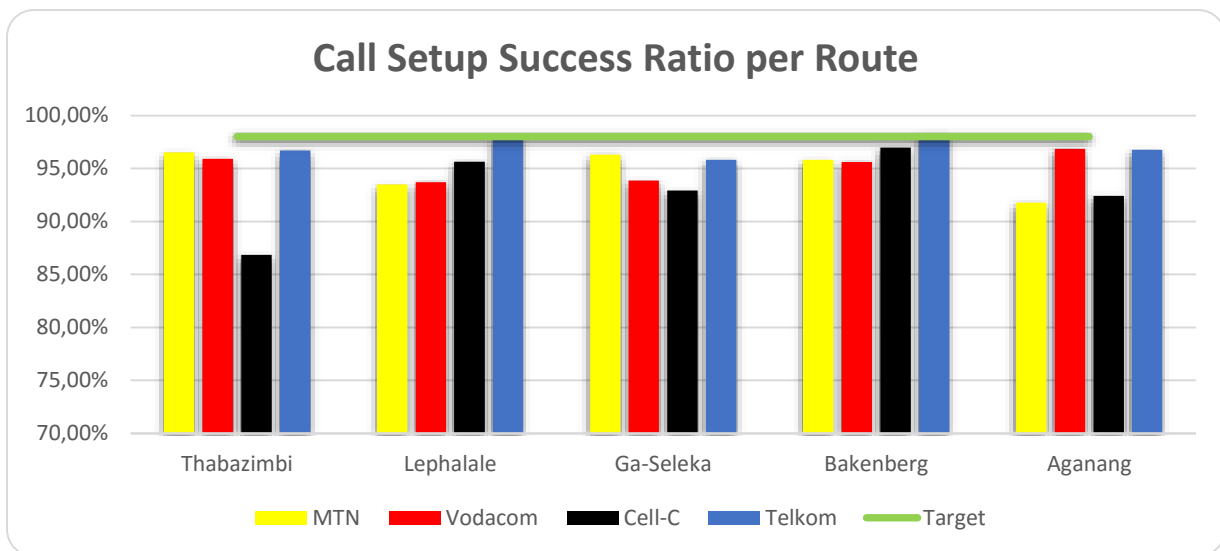


Figure 2: Call Setup Success Ratio (CSSR) per Route

Figure 2 above shows that Telkom met the 98% CSSR target in Lephalale and Bakenberg but failed to meet the target in Thabazimbi, Ga-Seleka and Aganang. The CSSR for Cell C, MTN and Vodacom was less than 98% in all areas, thus these operators failed the Accessibility target in all the areas of interest.

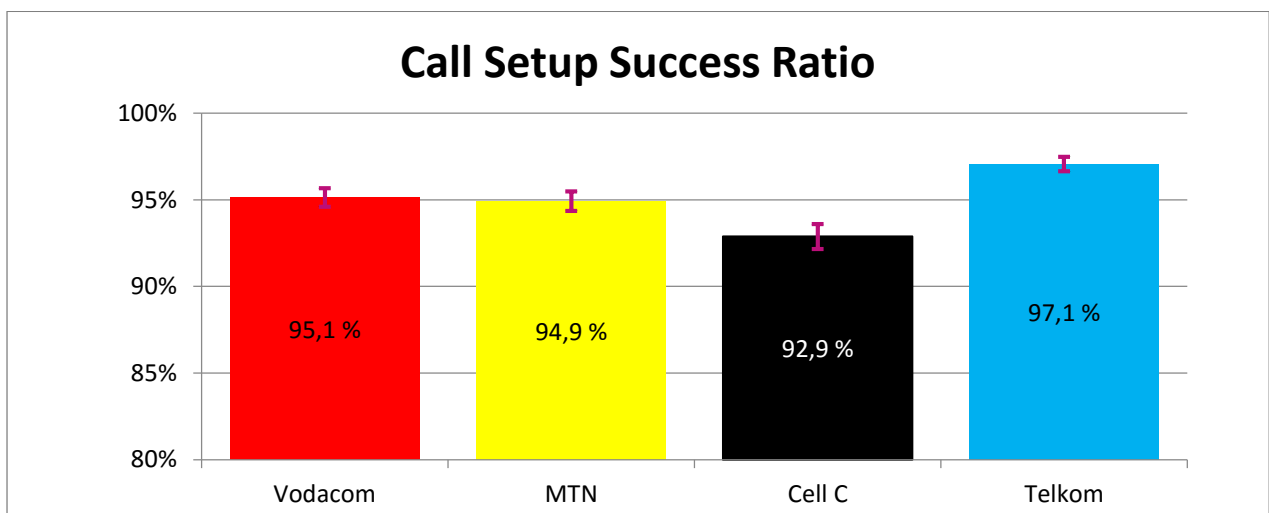


Figure 3: Overall Call Setup Success Ratio with Statistical Significance

Figure 3 above shows that Telkom’s overall CSSR is the highest, followed by Vodacom, MTN and Cell C in a descending order. None of the operators met ICASA’s CSSR target of above 98% as per “End-User and Subscribers Service charter regulations of 2016”. There was no statistical significant difference between MTN and Vodacom results. Telkom results show statistical significance difference in relation to other operators’ results. Telkom recorded the highest CSSR of 97.07% and Cell C was the lowest with 92.9%.

3.1.2 Drop Call Ratio (DCR)

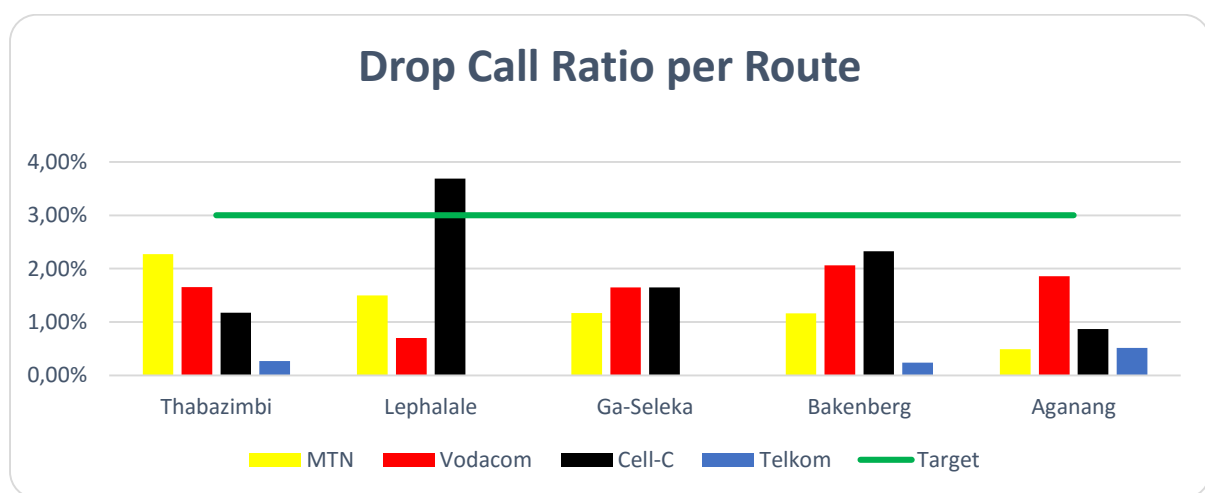


Figure 4: Drop Call Ratio (DCR) per Route

Figure 4 above shows that MTN, Telkom and Vodacom met the below 3% DCR target in all target areas (Thabazimbi, Lephalale, Ga-Seleka Bakenberg and Aganang). Cell C failed to meet the target only in Lephalale, but met the target in all other areas.

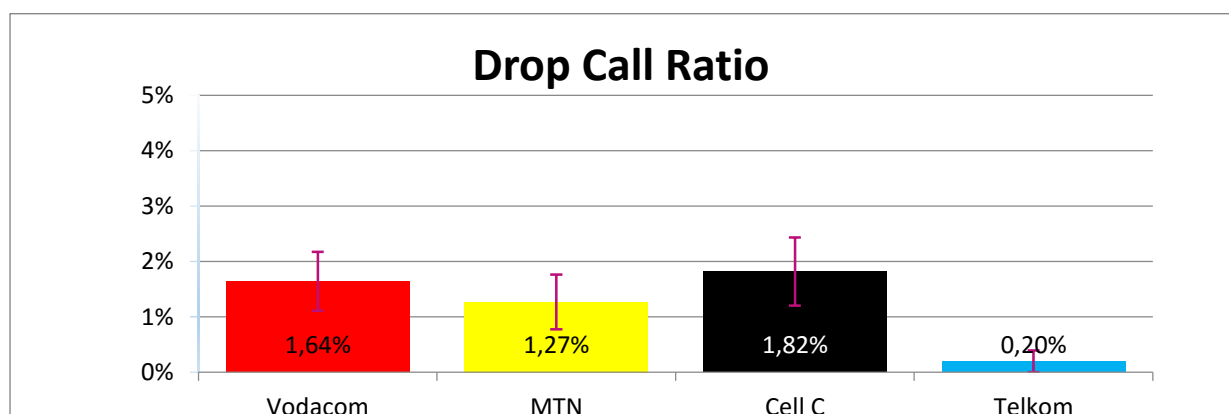


Figure 5: Total Drop Call Ratio with Statistical Significance

Figure 5 above shows that Telkom’s overall DCR is the lowest followed by MTN, Vodacom and Cell C in the respective ascending order. All operators met ICASA’s 3% DCR target. There is no statistical significant difference recorded between Cell C, MTN and Vodacom results. There is a statistical significant difference between Telkom and other operators (Vodacom, MTN and Cell C).

3.2 Analysis of the serving technology

The serving technology distribution were based on the device used and the network parameter configuration which varies with the mobile operators. The percentage distribution represents the fraction sampling points, out of the total of sampling points for all results, where the system was on a radio access technology. Figure 6 below shows the statistical distribution of the serving technology during the drive test. Telkom, MTN and Cell C serving technology distribution was mainly on GSM, while Vodacom distribution on both WCDMA and GSM technologies while Vodacom distribution was even on GSM and WCDMA.

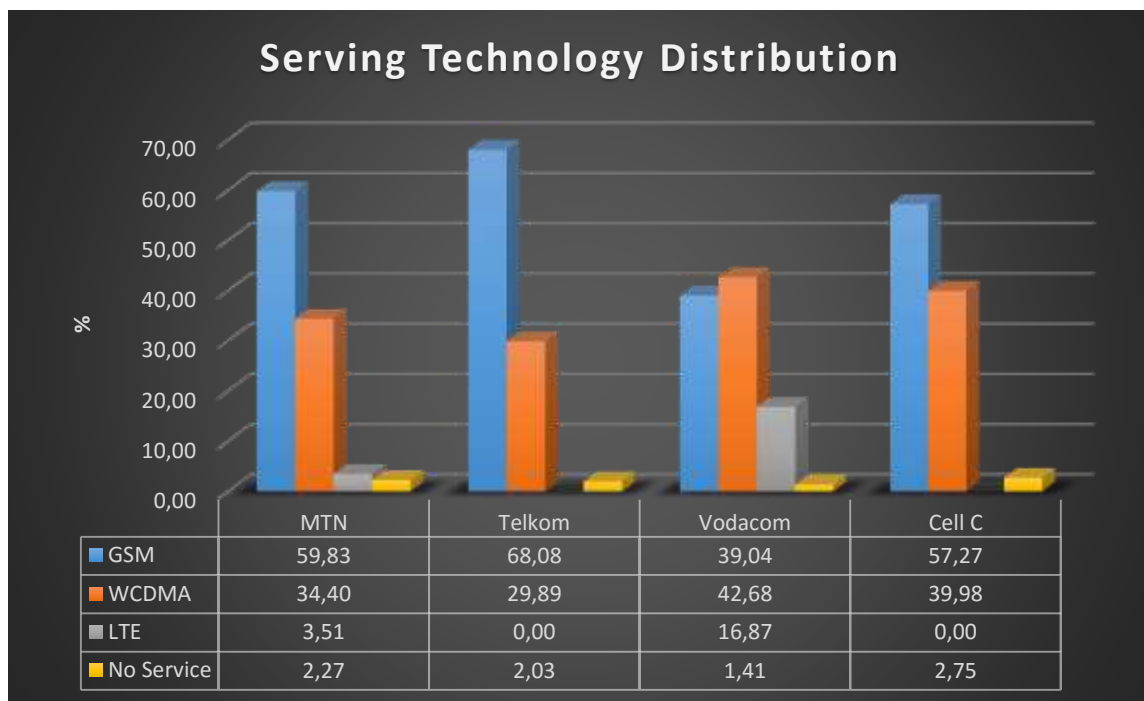


Figure 6: Technology Distribution

The maps in Appendix 6.3.2 show the geographic areas where the radio access technology was selected by the mobile device.

4 Responses to measurement results from operators.

A draft report similar to section 1, 2, 3, 5 and 6 of this report, was provided to operators for their comments. Also provided were the log files with all measurement results. The information enables operators to critically review the Authority's measurements and to give comments on that, as well as a network improvement plan. The responses from the operators are summarised in Appendix 6.2

5 Conclusion

This section provides the summary and key findings of all measurements. The obtained results illustrate a snapshot of the mobile network performance and customer experience within the measured time and location context.

The results indicate that the End-Users Quality of Service and operators' network performance varies significantly on per location basis.

After benchmarking the operators, the results show that in terms of overall Call Setup Success Ratio, all operators' results were below the target of 98%, thus Accessibility target was not met. In terms of overall Drop Call Ratio, all operators met the DCR target of less than 3%, thus meeting the Retainability target.

6 Appendixes

6.1 Appendix A: Detailed test results

Table 4: Drop call ratio (DCR) per Route

Route Name	Operator	Phase 1			Phase 2			TOTAL		
		Call Established	Call Dropped	DCR	Call Established	Call Dropped	DCR	Call Established	Call Dropped	DCR
Thabazimbi	Telkom	203	1	0.49%	167	0	0.00%	370	1	0.27%
	Cell C	165	1	0.61%	175	3	1.71%	340	4	1.18%
	Vodacom	190	2	1.05%	174	5	2.87%	364	7	1.92%
	MTN	175	6	3.43%	179	2	1.12%	354	8	2.26%
Lephalale	Telkom	146	0	0.00%	121	0	0.00%	267	0	0.00%
	Cell C	151	8	5.30%	147	3	2.04%	298	11	3.69%
	Vodacom	153	1	0.65%	132	1	0.76%	285	2	0.70%
	MTN	133	2	1.50%	134	2	1.49%	267	4	1.50%
Ga-Seleka	Telkom	284	0	0.00%	274	0	0.00%	558	0	0.00%
	Cell C	263	6	2.28%	269	2	0.74%	532	8	1.50%
	Vodacom	409	6	1.47%	263	5	1.90%	672	11	1.64%
	MTN	250	4	1.60%	264	2	0.76%	514	6	1.17%
Bakenberg	Telkom	215	0	0.00%	201	1	0.50%	416	1	0.24%
	Cell C	144	3	2.08%	157	4	2.55%	301	7	2.33%
	Vodacom	195	5	2.56%	212	0	0.00%	407	5	1.23%
	MTN	218	5	2.29%	193	3	1.55%	411	8	1.95%
Aganang	Telkom	205	1	0.49%	307	1	0.33%	512	2	0.39%
	Cell C	162	3	1.85%	328	5	1.52%	490	8	1.63%
	Vodacom	210	5	2.38%	347	2	0.58%	557	7	1.26%
	MTN	196	2	1.02%	352	4	1.14%	548	6	1.09%

Table 5: Call Setup Success Ratio (CSSR) per Route

Route Name	Operator	PHASE 1				PHASE 2				TOTAL			
		Call Attempt	Call Setup	User Busy	CSSR (%)	Call Attempt	Call Setup	User Busy	CSSR (%)	Call Attempt	Call Setup	User Busy	CSSR (%)
Thabazimbi	Telkom	515	494	2	96.30%	620	593	9	97.05%	1135	1087	11	96.71%
	Cell C	587	489	1	83.45%	451	410	2	91.31%	1038	899	3	86.86%
	Vodacom	694	652	1	94.08%	673	658	0	97.77%	1367	1310	1	95.90%
	MTN	720	707	0	98.19%	570	536	2	94.37%	1290	1243	2	96.51%
Lephalale	Telkom	459	440	10	98.00%	442	399	35	98.03%	901	839	45	98.01%
	Cell C	468	436	2	93.56%	407	397	2	98.02%	875	833	4	95.64%
	Vodacom	531	514	2	97.16%	528	470	7	90.21%	1059	984	9	93.71%
	MTN	461	452	0	98.05%	416	368	0	88.46%	877	820	0	93.50%
Ga-Seleka	Telkom	478	426	14	91.81%	945	885	14	97.90%	1396	1311	28	95.83%
	Cell C	578	551	6	96.33%	442	379	13	88.34%	1020	930	19	92.91%
	Vodacom	672	597	8	89.91%	994	957	2	96.47%	1666	1554	10	93.84%
	MTN	812	784	6	97.27%	331	307	4	93.88%	1143	1091	10	96.29%
Bakenberg	Telkom	634	614	11	98.56%	740	724	2	98.10%	1374	1338	13	98.31%
	Cell C	544	527	0	96.88%	512	491	6	97.04%	1056	1018	6	96.95%
	Vodacom	592	553	3	93.89%	436	426	1	97.93%	1028	979	4	95.61%
	MTN	748	740	0	98.93%	669	616	2	92.35%	1417	1356	2	95.83%
Aganang	Telkom	608	577	13	96.97%	723	678	21	96.58%	1331	1255	34	96.76%
	Cell C	564	500	4	89.29%	393	377	4	96.92%	957	877	8	92.41%
	Vodacom	694	668	5	96.95%	549	528	3	96.70%	1243	1196	8	96.84%
	MTN	613	572	3	93.77%	559	488	14	89.54%	1172	1060	17	91.77%

6.2 Appendix B: Summary of operator's responses

A summary of the response received from operators is provided below.

6.2.1 Vodacom

Vodacom submitted that it has reviewed the Authority report and shared the following remedial action to address poor coverage and quality of service in the areas:

- Ga-Seleka – Two new sites in Friendship and Bangalong went live in August 2017.
- A total of 24 planned sites for the 2018/19 financial year are distributed in the five areas which were covered during measurement. 14 out of 24 planned sites are within the Aganang area.
- One new site for each area of Lephalale, Thabazimbi and Ga-Seleka scheduled to be on air within the next 6 months.

Network optimisation activities were conducted after the report was shared with Vodacom.

6.2.2 MTN

MTN reviewed the Authority's draft and submitted the following remedial action to address poor coverage and service quality in the areas:

- Thabazimbi route - Two additional sites in Thabazimbi, which were in the process of being built at the time of the drive test, came on air on the 5 and the 18 July 2017 respectively.
- Lephalale route – One new site was activated on the 26 June 2017 post the Authority's drive test.
- Ga-Seleka route – Additional site activations are currently scheduled for quarter 4 of 2017.
- Bakenberg route – GSM interference was observed in the area. MTN conducted frequency optimisation to alleviate interference.
- Aganang route – MTN is currently conducting frequency optimisation in this area and an additional site is currently scheduled for quarter 4 of 2017.

Notwithstanding the additional sites already implemented and those commissioned in Ga-Seleka and Aganang routes, a total of eight additional sites have been planned are expected to be live by year end in the area where the Authority did the drive tests.

6.2.3 Cell C

Cell C highlighted the lack of its own continuous coverage in some of the areas tested. In some areas Cell C relies on national roaming arrangements with Vodacom's network. In summary, the poor performance was attributed by the following:

- The dropped calls and call setup failures due to low signal levels and insufficient transmission capacity, respectively.
- Lack of seamless roaming/handover between Cell C and Vodacom network. Cell C relies on its national roaming arrangement with Vodacom in some of the areas specified in the Authority's report. Roaming provides coverage where Cell C's own network does not have coverage.

Despite roaming arrangements, there are projects planned to have new base-station sites, to have capacity and transmission routes improved and optimised in the low-performing areas.

Cell C's plans and remedies in the low performance areas include:

- New sites that are planned to be rolled out in the next 3 years.
- Implementation of seamless roaming in future.
- Optimisation and capacity initiatives to improve network quality and coverage.

6.2.4 Telkom

Telkom was pleased with the Authority's report and highlighted the following in its response:

- The problem of the lack of 900 MHz frequency band, which is a crucial requirement for the cost-effective deployment of national coverage specifically in rural areas.

- Within the Limpopo test area, about 93% of tests were made on MTN's network on which Telkom is roaming and 7% on Telkom's own network. However, Telkom met the DCR (Drop Call Ratio) target of less than 3% in all five test areas and CSSR (Call Setup Success Ratio) target of more than 98% in two of the three areas.

Although the ICASA drive testing only gives a snapshot of network performance on the specific day and time and not a true representation of the overall network performance, Telkom takes the results as input to further improve the quality of its networks in these areas. Telkom's plans and remedies in the low-performance areas are as follows:

- In Ga-Seleka and Aganang, Telkom currently has no sites planned and will continue to depend on our roaming agreement to provide voice services in these areas.
- In the Thabazimbi area, Telkom already planned additional sites, which will increase overall network quality.
- Further engagement with the roaming partner regarding network improvements in the areas where Telkom subscribers roam on MTN's network.

6.3 Appendix C: Coverage maps

6.3.1 Signal level measurements

6.3.1.1 Vodacom

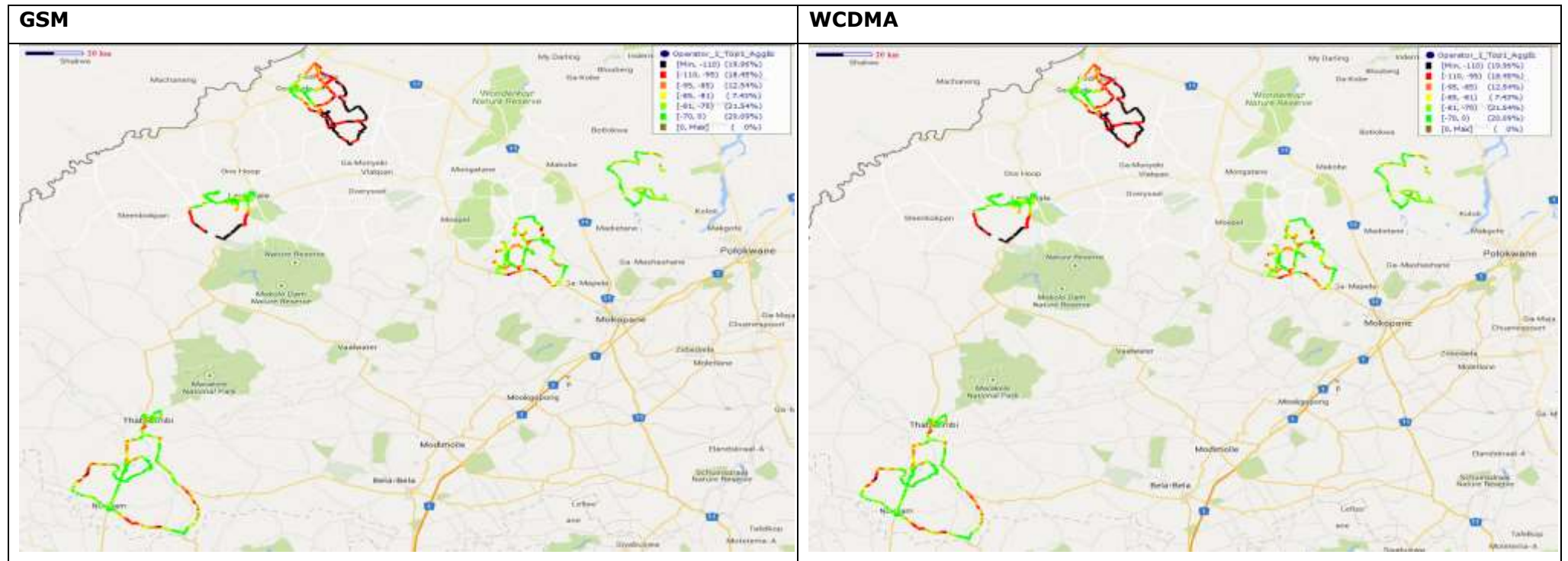


Figure 7: Limpopo Province - Vodacom GSM and WCDMA Signal Levels

6.3.1.2 MTN

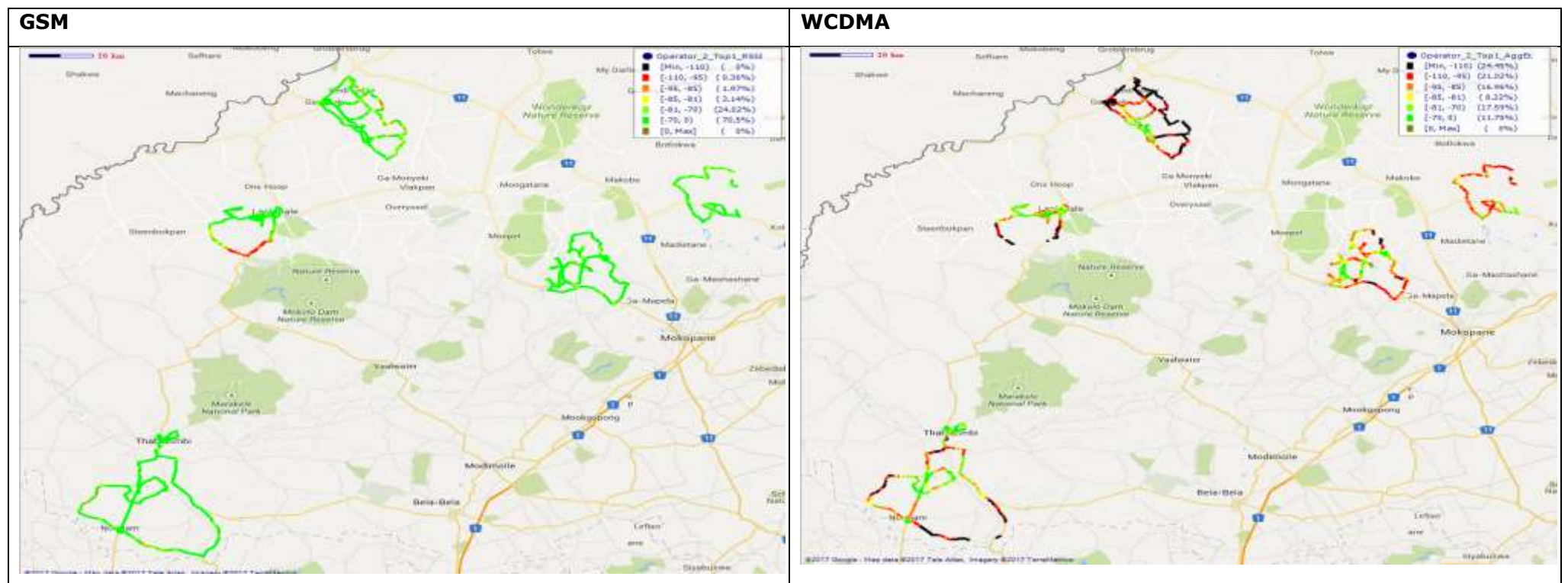


Figure 8: Limpopo Province - MTN GSM and WCDMA Signal Levels

6.3.1.3 Cell C

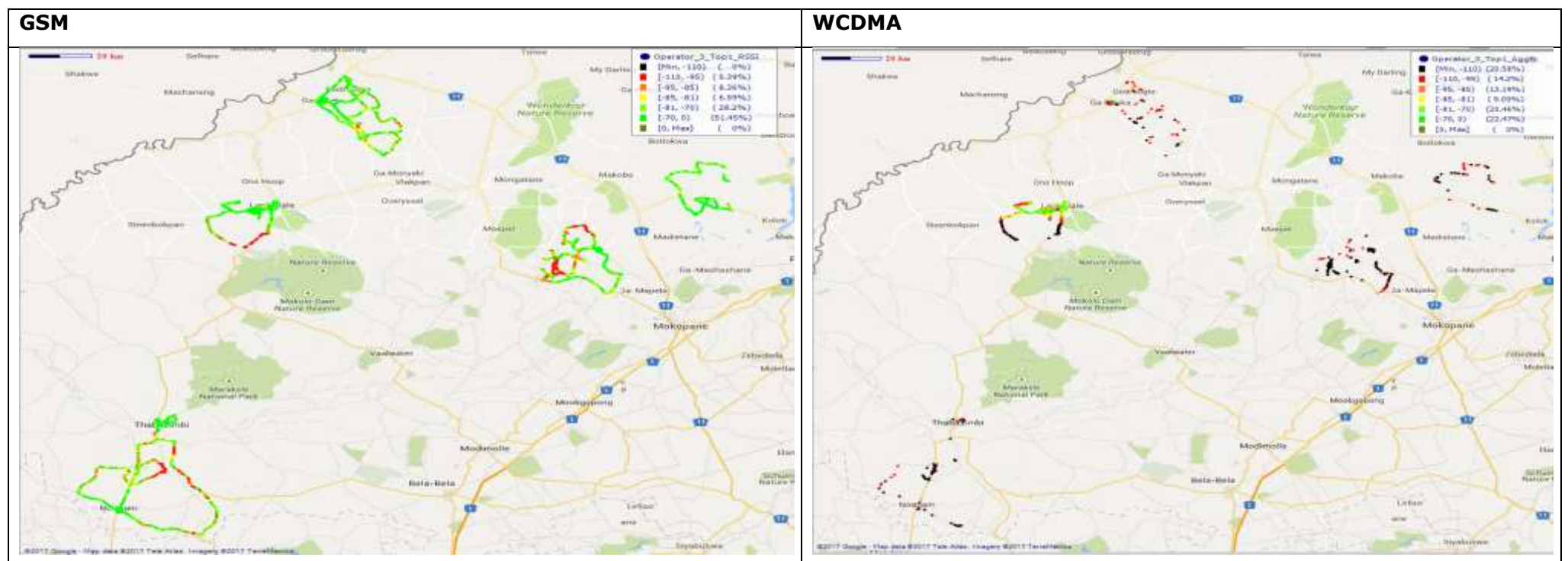


Figure 9: Limpopo Province - Cell C GSM and WCDMA Signal Levels

6.3.1.4 Telkom

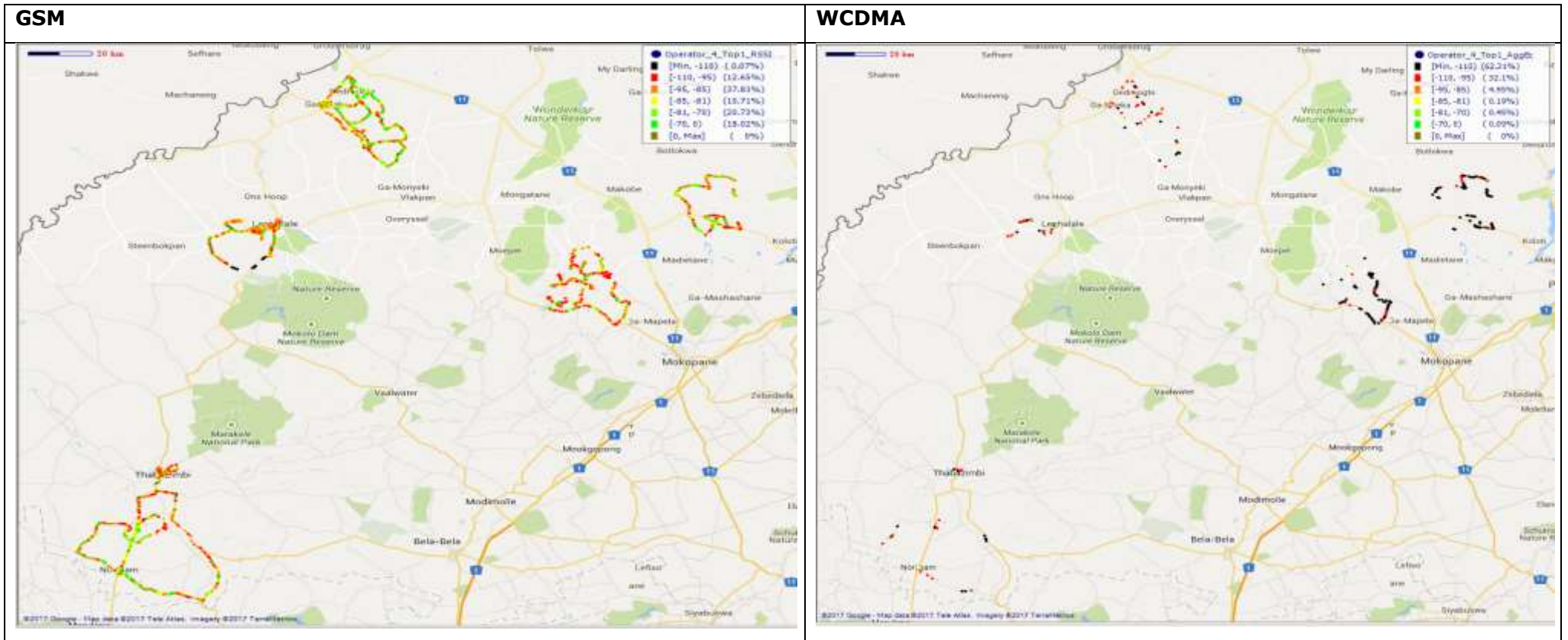


Figure 10: Limpopo Province - Telkom GSM and WCDMA Signal Levels

6.3.2 Serving technology maps

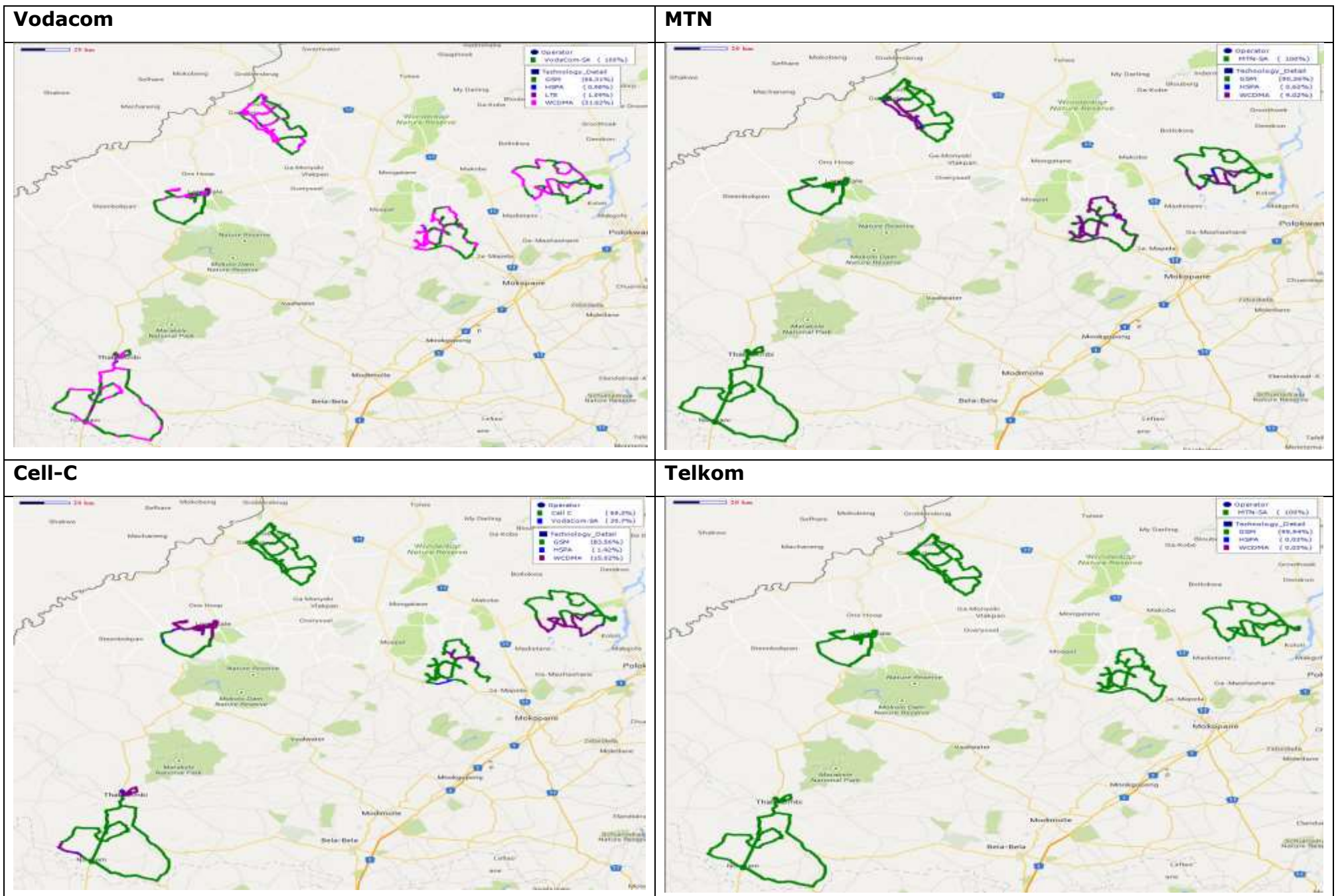


Figure 11: Limpopo Province Serving Technology Plot

