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**2021/2022 Quarter 3:  
Voice Quality of Service  
Report  
Limpopo Province**

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## List of Abbreviations

CD	Call Duration
CSFB	Circuit Switched Fall Back
CRR	Call Retention Ratio
CSSR	Call Setup Success Ratio
CST	Call Setup Time
DCR	Drop Call Ratio
GSM	Global System for Mobile Communications
HD	High Definition
ICASA	Independent Communications Authority of South Africa
IVR	Interactive Voice Response
KPI	Key Performance Indicator
LTE	Long-Term Evolution
LTE-A	Long-Term Evolution Advanced
R&S	Rohde & Schwarz
MOC	Mobile Originating Call
MOS	Mean Opinion score
POLQA	Perceptual Objective Listening Quality Analysis
WCDMA	Wideband Code Division Multiple Access
VoLTE	Voice over Long-Term Evolution

## 1. Executive Summary

The Independent Communications Authority of South Africa (ICASA) appointed Metro Global Telecom Services (Pty) Ltd. (MetroTelworks) to conduct Quality of Service (QoS) measurements on the networks of mobile operators; Cell C, MTN, Telkom and Vodacom. The measurements were performed to monitor performance of mobile voice services offered by the operators in the Limpopo Province. The measurements were carried out in the period 17 November to 4 December 2021, covering a total distance of over 3081 kilometres.

The purpose of conducting QoS measurements was to monitor and analyse the quality of mobile voice service as experienced by the end-user. The results were later benchmarked against the QoS standards 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 towns, townships, farm areas, rural areas, and economic activity nodes. The sampled areas within the Limpopo Province were Ga-Seleka, Lephalale, Modimolle, Mokopane and Shongoane.

A vehicle equipped with Rohde and Schwarz Smart Benchmarker II testing system, and 12 mobile phones was used to collect data in mobility conditions. The four Key Performance Indicators (KPIs) used to assess QoS are Accessibility, Retainability, Call Setup Time and Speech Quality. The Drop Call Ratio (DCR) KPI is used to measure the user's ability to successfully complete a call and Call Setup Success Ratio (CSSR) KPI measures the user's ability to initiate a phone call.

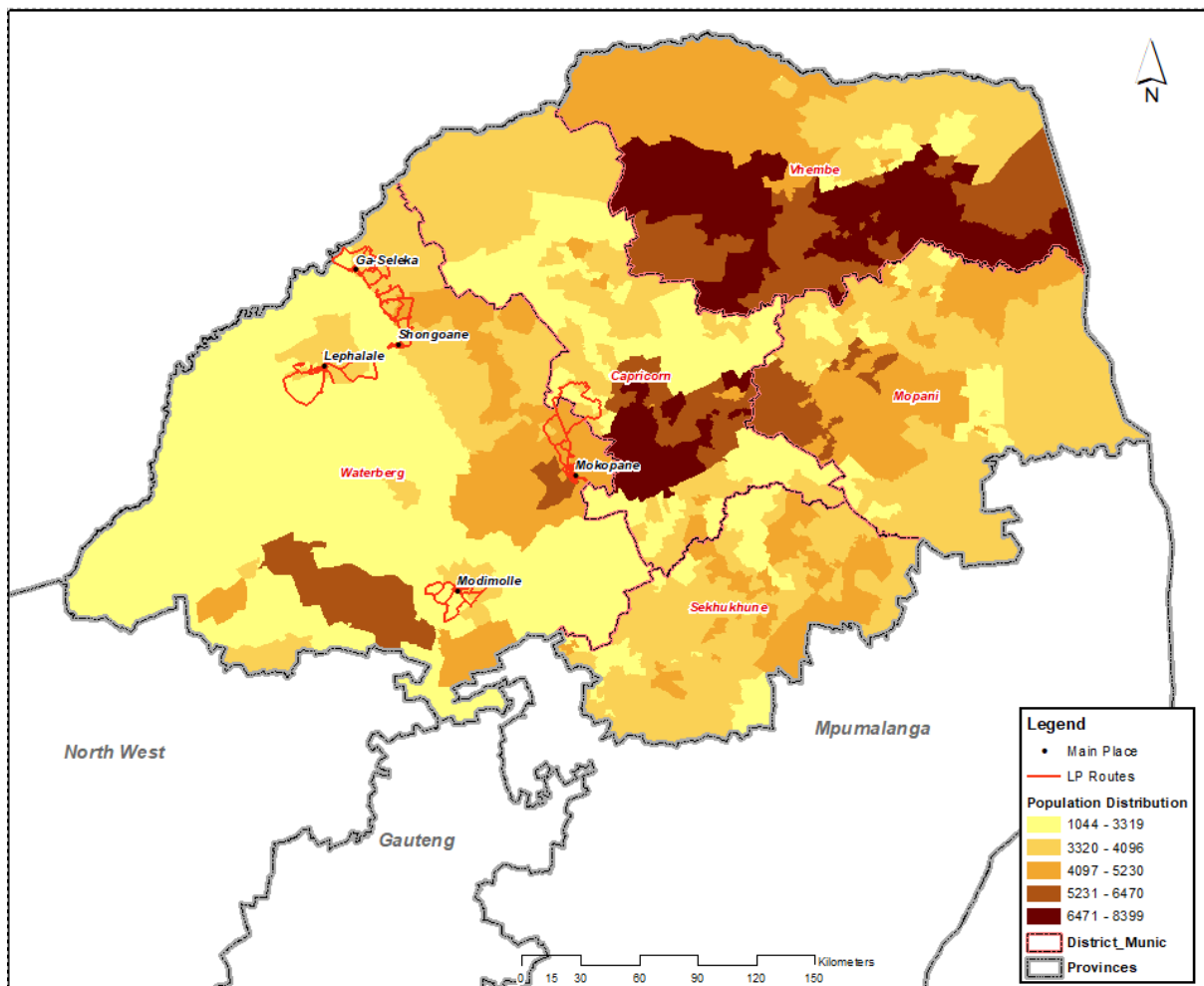
According to the End-User and Subscriber Service Charter Regulations of 2016, the average DCR should be less than 3% and the average CSSR should be greater than 98%. The average Call Setup Time must be less than 20 seconds and the score for the average Speech Quality must be greater than 3.

The results show that in terms of overall Call Setup Success Ratio for the Limpopo Province, all operators achieved less than 98% CSSR, thus failing to meet the Accessibility target. However, all operators achieved overall Drop Call Ratio of less than 3% thus successfully meeting the target. All operators met the Call Setup Time target of less than 20 seconds. All operators successfully achieved the overall Speech Quality Target of greater than 3.

## 2. Introduction

ICASA's mission is to regulate electronic communications, broadcasting, and postal services in the public interest. The Authority ensures the quality of service through its Quality of Service (QoS) monitoring activities. The Authority appointed Metro Global Telecom Services (Pty) Ltd. (MetroTelworks) to conduct drive testing in selected areas of the Limpopo Province. The test was focused on monitoring the cellular voice telephony service being offered by Cell C, MTN, Telkom and Vodacom within the Limpopo Province.

The QoS monitoring was conducted in areas that fall under the Waterberg District Municipality. The areas of interest that were selected within this municipality were Ga-Seleka, Lephalale, Modimolle, Mokopane and Shongoane. The areas consist of major towns, townships, farm areas, rural areas, major road arteries, economic activity nodes and areas of previous complaints.



*Figure 1. Limpopo Province Route Map with Population Distribution*



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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 Call Accessibility, Call Setup Time, and Call Retainability and Speech Quality parameters.

- a) Call Accessibility is reported as a percentage and is a measure of the number of times a user can successfully establish a call as a ratio of the total calls attempted. It is measured using Call Setup Success Ratio (CSSR).
- b) Call Setup Time is the time interval from the instant a user initiates a mobile call request until a complete message indicating call disposition is received by the calling terminal. It is measured from the time a user presses the dial button until the user gets connected to the dialled party.
- c) 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 call. It is measured using Drop Call Ratio (DCR).
- d) Speech Quality is the condition of conversational speech without noise and echo interference. It is measured using the Mean Opinion Score (MOS).

### 3. Methodology

A minimum of 200 test samples per network operator were collected for each area tested over two phases of data collection. 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 on the selected routes and particular time of the day, which may not be a true representation of the mobile service provider's overall network performance, however, it is considered statistically relevant.

Voice test set-up consisted of two test scenarios namely, short calls and long calls which are defined in this section. The short calls were used to measure Call Accessibility and Call Setup Time(s) whilst the long calls were used to measure Call Retainability and Speech Quality. The Long Call scenario required the use of two test mobiles per Operator i.e., call initiating side (A-side) and call receiving side (B-side). The Short Call scenario required the use of a single test mobile for each Operator making calls to the Operators IVR system. This set-up results in three mobile devices per operator bringing the total number of devices used for the test to twelve with three for each Mobile Operator. The Call Windows were set up as follows: Call duration + 30 seconds, (for the setup and release phases) + 30 seconds (for the minimum pause interval after call termination). The call duration for the long call was set at 120 seconds bringing the total call window size to 180 seconds with the short call duration set at 10 seconds resulting in a total call window of 70 seconds. The audio quality of speech samples was evaluated using the HD-voice capable and ITU standardized POLQA wideband algorithm with 10 samples being recorded during each call.

The devices were set to select the best available technology whilst the test SIMs in use were not activated for VoLTE services, although some operators may activate this setting via the air interface from time to time. With this setup, in areas where operators had LTE, they performed Circuit Switched Fall Back (CSFB) calls.

Voice testing was done in two phases with a measurement window gap of at least seven days in between both measurements.

### 3.1. Equipment test setup and configuration

#### 3.1.1. System used



The Test Equipment used was the Rohde & Schwarz SwissQual Benchmark II platform with Sony XZ Premium smartphones installed inside the car using the R&S Phone Mount Walls. Four mobile devices were used for Short Call and eight mobile devices were used for Long Call. The mobile devices were configured to automatically select a mobile network and radio access technology.

technology.

#### 3.1.2. Device Description

The Sony Xperia XZ Premium Smartphone was selected as the measurement User Equipment (UE) for Voice Services. It supports the following technologies: GSM, HSPA, LTE and LTE-A.

#### 3.1.3. Short and Long Call Windows

Figure 2 shows the call windows for the long and short calls as highlighted in the methodology section.

##### Short Call:



##### Long Call:



Test Scenar..	Value
Short Call	Call Duration = 10s
	Call Setup timeout = 30s
	Call Window = 70s
Long Call	Call Duration = 120s
	Call Setup timeout = 30s
	Call Window = 180s
POLQA (WB)	

Figure 2. Call Window Duration

### 3.2. Route selection

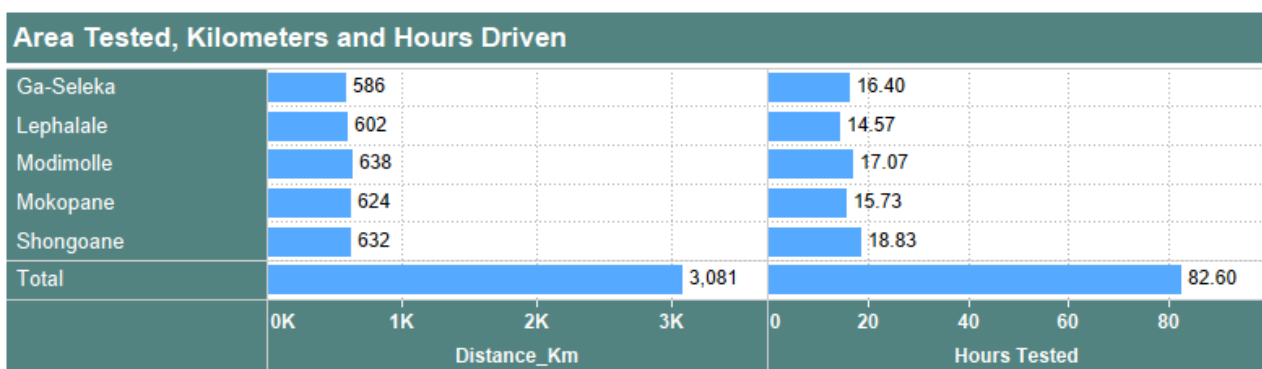
Measurement routes were selected so that they would reflect end user distribution at different geographical locations in areas where people live and use mobile phones - major towns, townships, farm areas, rural areas, major road arteries, economic activity nodes and areas of previous complaints. The selected five areas in which the QoS measurements were conducted are within Waterberg District Municipality as indicated in Table 1.

*Table 1. Test timeline for area covered*

Routes and Dates			
District	Area	Dates	Phase
Waterberg	Modimolle	17/11/2021 and 18/11/2021	Phase1
		26/11/2021 and 29/11/2021	Phase 2
	Mokopane	19/11/2021	Phase1
		30/11/2021	Phase 2
	Lephalale	22/11/2021	Phase1
		01/12/2021	Phase 2
	Ga-Seleka	23/11/2021	Phase1
		02/12/2021	Phase 2
	Shongoane	24/11/2021 and 25/11/2021	Phase1
		03/12/2021 and 04/12/2021	Phase 2

Table 2 shows the total distance covered in each area for both phases and active measurement duration.

*Table 2. Distance and time driven per area*



### 3.3. Measurement parameters and targets

#### 3.3.1. Parameters

##### 3.3.1.1. 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 attempts. The formula to calculate CSSR is shown below:

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

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

##### 3.3.1.2. 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, are dropped, or interrupted prior to the deliberate completion by the user. The formula to calculate DCR is shown below:

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

Where, D = number of dropped calls and S = number of successful calls established

##### 3.3.1.3. Call Setup Time [s]

Call Setup Time is the time interval from the instant a user initiates a network connection request until a complete message indicating call disposition is received by the calling terminal. It is measured from the time a user presses the dial button until the user gets connected to the dialled party.

##### 3.3.1.4. Speech Quality (Mean Opinion Score)

Speech quality on call basis is an indicator representing the end-to-end speech transmission quality of the mobile telephony service. This parameter computes the speech quality on the basis of completed calls. Measurement made use of the POLQA Algorithm which compares the reference signal received from the transmitting side against an equivalent sample on the receiving side.

#### 3.3.2. Targets

According to the End User and subscriber Service Charter Regulations of 2016, the following voice parameters' targets are defined as follows:

1. Call Setup Success Ratio – Average Call Setup Success Ratio must be greater than 98%.
2. Call Setup Time Ratio – Average Call Setup Time must be less than 20 seconds.
3. Drop Call Ratio – Average Drop Call Ratio must be less than 3%.

4. Speech Quality – Average Speech Quality of MOS must be greater than 3.

## 4. Results and Analysis

This section provides a summary of the mobile operators' performance results based on the drive test route in the following test areas: Ga-Seleka, Lephalale, Modimolle, Mokopane and Shongoane.

### 4.1. Accessibility, Retainability, Call Setup Time and Quality Measurements

#### KPI Results per Area

Table 3 shows a summary of KPIs results per area. All operators failed to achieve the target for Call Accessibility in three of the five tested areas (Lephalale, Modimolle and Mokopane). Cell C and MTN achieved the Accessibility target in Ga-Seleka and Shongoane. Vodacom met the Accessibility target only in Shongoane. Telkom failed to meet the Accessibility target in all the tested areas. All operators achieved the Call Retainability target in Lephalale and Shongoane.

MTN met the Retainability target in all the tested areas. Cell C failed to achieve the Call Retainability target in Modimolle and Vodacom in Mokopane. Telkom failed to achieve the target in Ga-Seleka, Modimolle and Mokopane. All the Operators met the Call Setup Time of less than 20 seconds in all the tested areas. MTN and Vodacom are the only Operators that met the Voice Quality MOS score of more than 3 in all the tested areas. Cell C failed to meet the Voice Quality target in Mokopane, and Telkom failed to meet the target in Ga-Seleka. Detailed results are provided in the Appendix 1 and Appendix 2.

*Table 3. Summary of KPI Results per Area*

		Ga-Seleka	Lephalale	Modimolle	Mokopane	Shongoane
Call Setup Success Ratio - [%]	Cell C	98.11%	92.62%	92.56%	90.99%	99.93%
	MTN	98.80%	94.86%	94.06%	92.74%	99.78%
	Telkom	91.92%	84.01%	94.34%	94.34%	96.25%
	Vodacom	96.65%	90.02%	95.61%	95.61%	98.95%
Drop Call Ratio [%]	Cell C	0.33%	2.05%	3.39%	1.88%	0.00%
	MTN	0.00%	0.78%	2.99%	1.84%	0.00%
	Telkom	3.14%	2.56%	3.03%	5.43%	0.30%
	Vodacom	0.69%	2.75%	0.67%	3.60%	0.29%
Call Setup Time [s]	Cell C	3.25	3.66	3.60	3.76	3.34
	MTN	2.56	2.97	2.82	2.90	2.58
	Telkom	3.55	4.26	4.09	4.24	4.06
	Vodacom	3.21	3.62	3.28	3.30	2.98
POLQA MOS	Cell C	3.10	3.02	3.01	2.99	3.13
	MTN	3.61	3.51	3.52	3.50	3.64

	<b>Telkom</b>	2.98	3.40	3.37	3.25	3.40
	<b>Vodacom</b>	3.33	3.36	3.56	3.38	3.44

#### 4.1.1. Call Accessibility (Short Call)

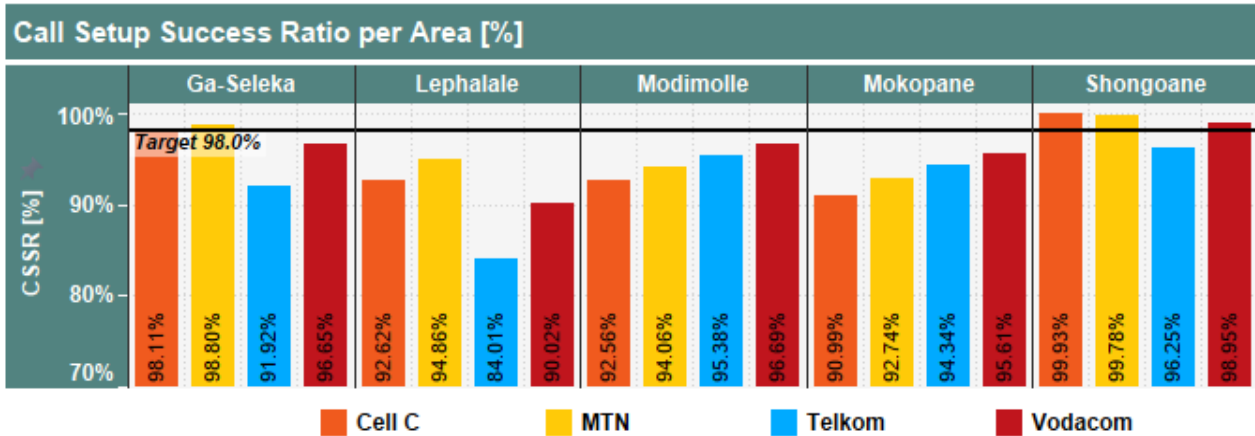


Figure 3. CSSR KPI per Area - Short Call

Figure 3 shows that all the operators failed to meet the 98% CSSR target in three of the five tested areas (Lephalale, Modimolle and Mokopane). Cell C and MTN were the only operators that achieved the CSSR target in Ga-Seleka and Shongoane. Vodacom met the Accessibility target only in Shongoane. Telkom failed to meet the Accessibility target in all the tested areas.

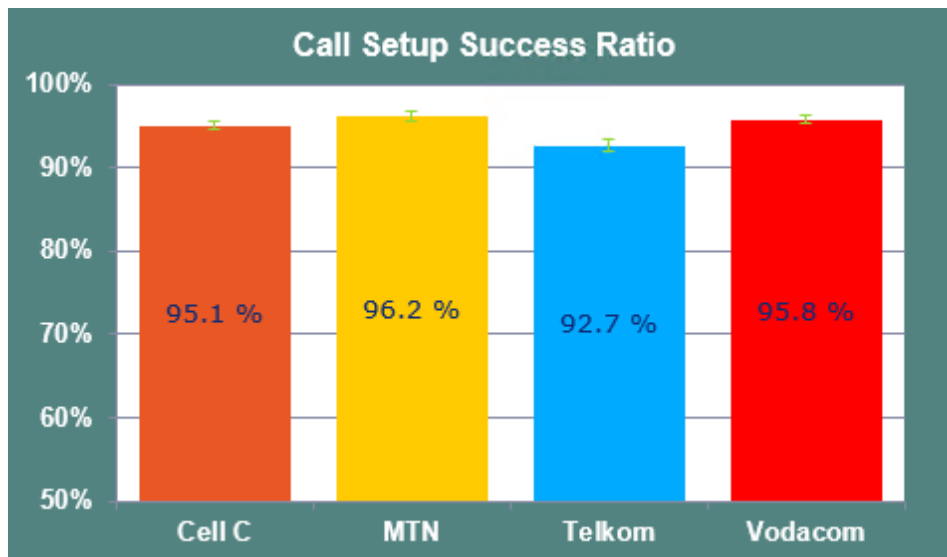


Figure 4. CSSR KPI Overall Results

Figure 4 shows that all operators failed to achieve the overall CSSR target of 98% for Limpopo Province. MTN's Overall CSSR is the highest followed by Vodacom, Cell C and Telkom in descending

order. There is statistical significance difference recorded between MTN and Telkom as well as MTN and Cell C.

#### 4.1.2. Drop Call Ratio (Long Call)

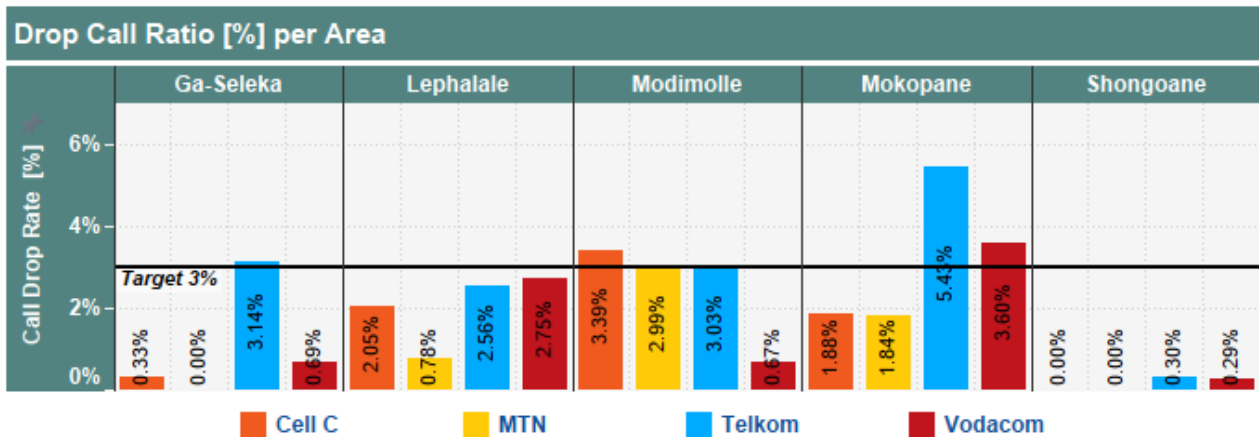


Figure 5. DCR KPI per Area Long Call

Figure 5 shows the DCR results per area for all the operators. All operators met the DCR target in two areas (Lephalale and Shongoane). MTN met the DCR target in all the tested areas. Cell C met the DCR target in four of the tested areas and failed in Modimolle. Vodacom met the DCR target in four of tested areas and failed in Mokopane. Telkom failed to achieve the target in Ga-Seleka, Modimolle and Mokopane.

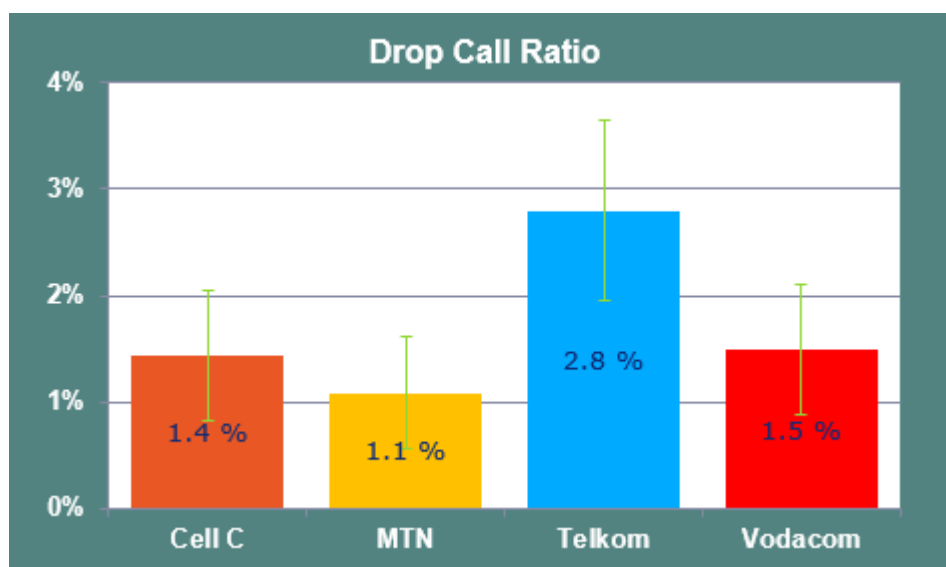


Figure 6. DCR KPI Overall Results



The overall results on Figure 6 shows that all operators successfully met the overall DCR target of less than 3%, MTN's overall DCR is the lowest followed by Cell C, Vodacom, and Telkom in ascending order. There is no statistically significant difference recorded between MTN and Vodacom, as well as MTN and Cell C. There is statistical significance difference recorded between MTN and Telkom.

#### 4.1.3. Call Setup Time (Short Call)

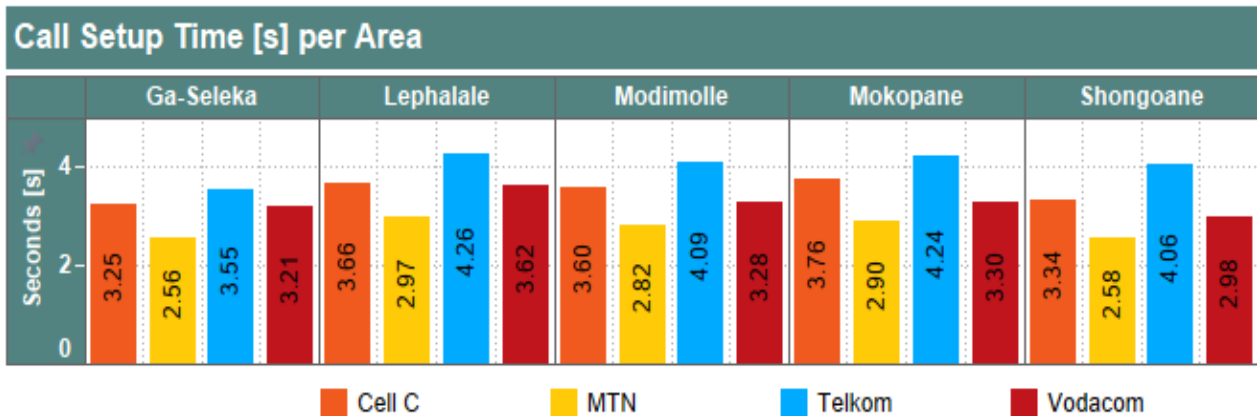


Figure 7. Call Setup Time[s] KPI per Area

Figure 7 shows that all operators met the Call Setup Time target of less than 20 seconds in all the tested areas as per the End-User and Subscribers Service Charter Regulations of 2016. MTN had the lowest CST in all the five tested areas: Ga-Seleka, Lephalale, Modimolle, Mokopane and Shongoane.

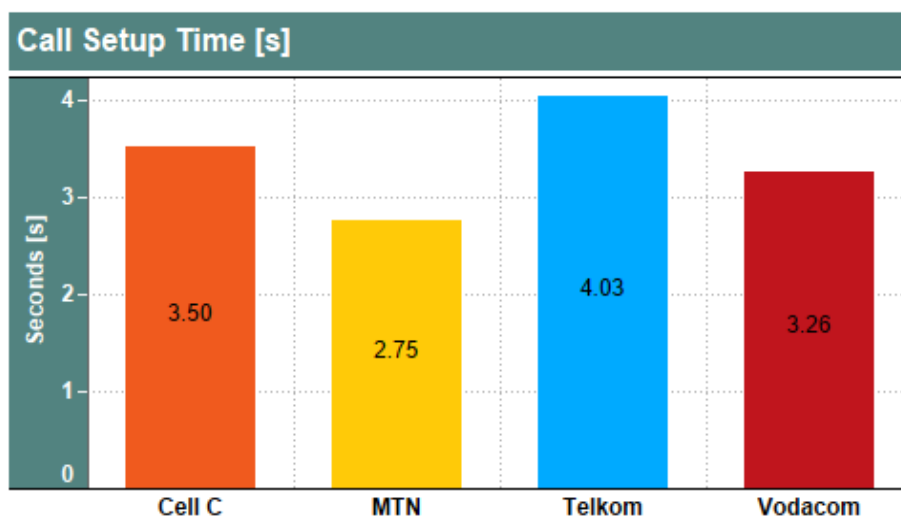


Figure 8. Call Setup Time[s] KPI Overall Results

Figure 8 shows the overall Call Setup Time results. MTN had the lowest overall Call Setup Time followed by Vodacom, Cell C and Telkom.

#### 4.1.4. POLQA MOS (Long Call)

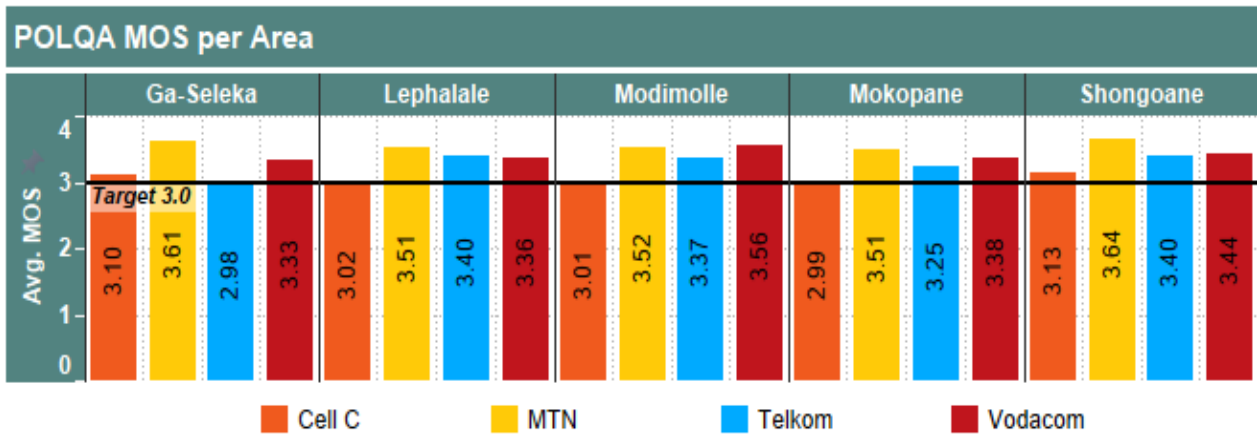


Figure 9. Speech Quality per Area

Figure 9 depicts speech quality results per tested area. Vodacom and MTN are the only operators that achieved an average POLQA MOS Score of at least 3 in all the areas tested. Telkom failed to meet the speech quality target only in Ga-Seleka. Cell C failed to meet the target for speech quality only in Modimolle.

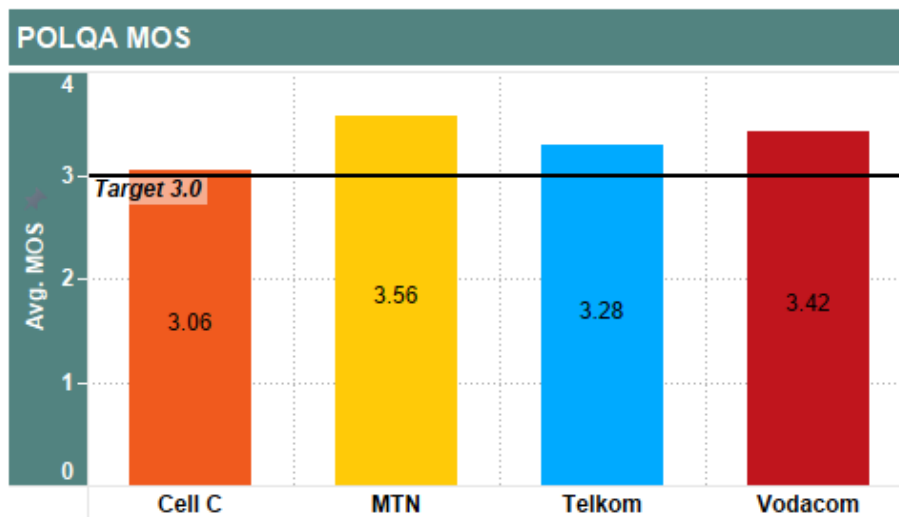


Figure 10. Speech Quality Overall Results

Figure 10 shows the overall Voice Quality scores for each operator. MTN achieved the best Overall Speech Quality followed by Vodacom, Telkom, and Cell C. All operators successfully met the required overall speech quality target score of 3.

## 4.2. Radio Technology

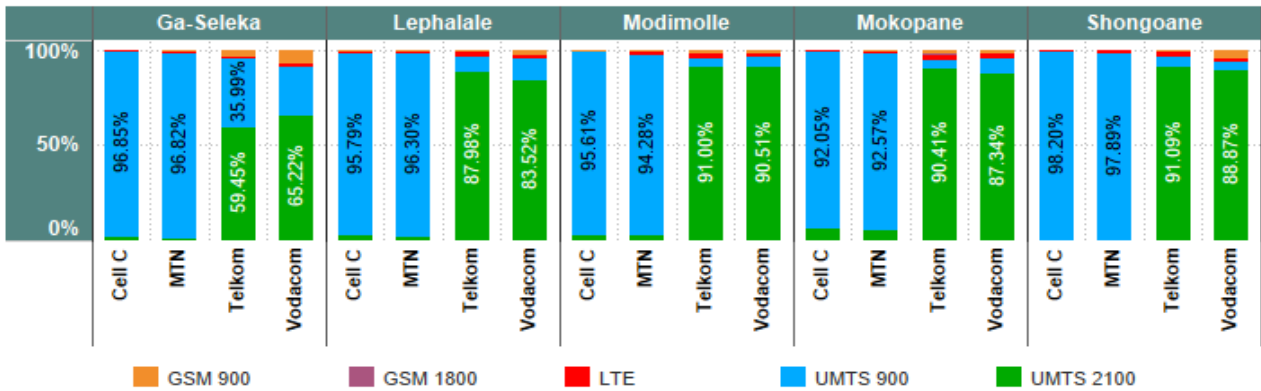


Figure 11. Serving Radio Technology per Area

Figure 11 shows the distribution of the serving radio technology per area. MTN and Cell C showed significant presence of UMTS 900 for all areas, while Vodacom and Telkom showed significant presence of UMTS 2100 for all areas.

Figure 12 shows the distribution of the overall serving technology during the drive test. All operators' serving technology was mainly on UMTS. Telkom and Vodacom showed presence of most samples on UMTS 2100. MTN have the highest UMTS 900 presence followed by Cell C, Telkom, and Vodacom in a descending order.

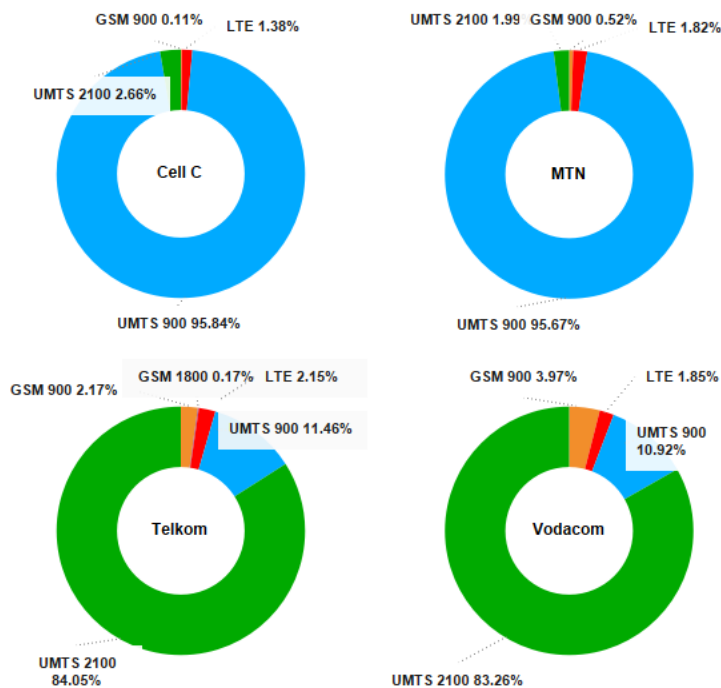


Figure 12. Serving Radio Technology Overall Results

### 4.3. CSFB

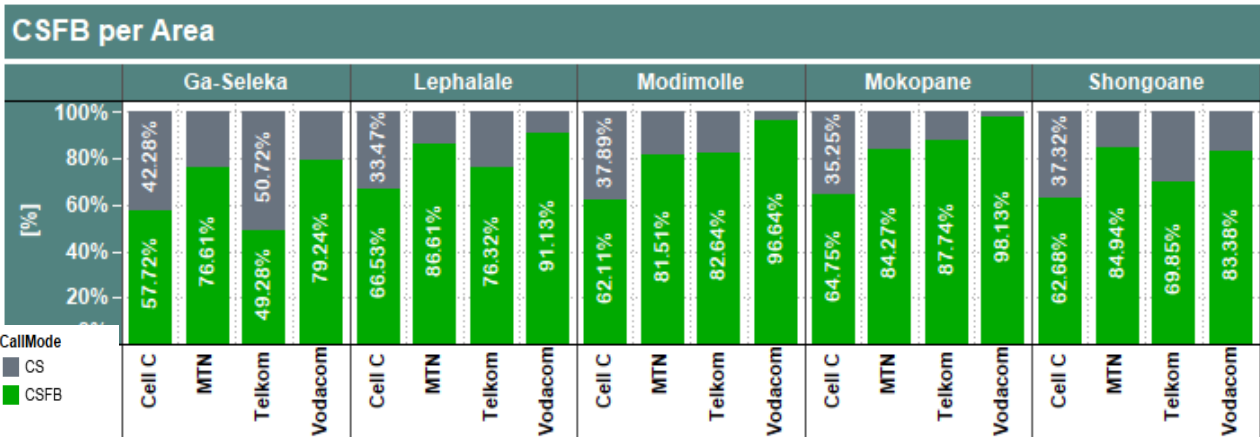


Figure 13. CSFB per Area

Figure 13 shows the breakdown of CS/CSFB calls per area. Vodacom, Telkom and MTN have most CSFB samples in all the areas. This is an indication that the three operators have significant LTE coverage in all the tested areas.

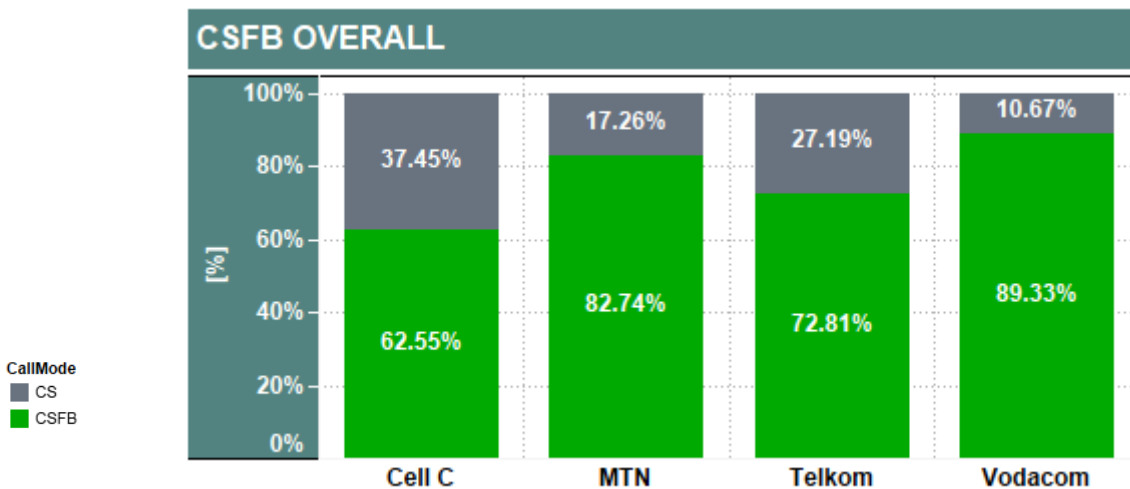


Figure 14. CSFB Overall Results

Figure 14 shows percentage of calls that were attempted on traditional networks as well as the ones initiated on LTE network and made CS fall back to UMTS/ GSM. Vodacom is seen with the most CSFB samples in overall results followed by MTN, Telkom and then Cell C.

## 5. Conclusion

This section provides the summary and key findings of the measurements. The 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-user's Quality of Service and Operators' network performance varies significantly per area tested. Below are the highlights: -

- **Best Performing Area:** Shongoane is the best performing area.
- **Worst Performing Areas:** All Operators failed to meet the CSSR target in Mokopane, Lephallale and Modimolle.
- **MTN** achieved the best overall Call Setup time with an average of 2.75 seconds.
- **Call Setup Success Ratio (CSSR):** Overall results show that all the operators failed to achieve 98% CSSR target. MTN achieved best CSSR with 96.2% followed by Vodacom with 95.8%. The results per area indicates that all operators failed to meet the CSSR target in Mokopane, Lephallale and Modimolle.
- **Drop Call Ratio (DCR):** All the operators achieved the overall Drop Call Ratio target (3%). MTN achieved lowest DCR (1.1%) followed by Cell C (1.4%).
- **Speech Quality (MOS):** All operators achieved speech quality target of MOS score of 3. MTN achieved best MOS score of 3.56 followed by Vodacom with score of 3.42.
- **Call Setup Time (CST):** All operators achieved the target according to the End-User and Subscribers Service Charter Regulation of 2016. MTN has the fastest overall Call Setup Time with an average of 2.75s, followed by Vodacom at 3.26s.

## 6. Appendices

### 6.1. Appendix 1: Mobile operators' feedback on the report

#### 6.1.1. Vodacom

Vodacom acknowledges network challenges that were experienced in Limpopo during QoS trial conduct by the Authority and provided remedial action. One of the major challenges in the teste areas is poor coverage due to large site inter-distance and external interference coming from a broadcaster on the Vodacom Band. Hilly terrain environment amplifies issues of poor to no coverage on district roads due to high inter site distance hence number of failures. Major challenge is road access and electricity to suitable positions where a radio tower could be deployed to cater for this kind of environment. The operator is exploring infrastructure sharing mainly with other operators to close coverage gaps between Vaalwater and Lephalale. The operator also indicated that the ongoing Power Load reduction and Site vandalisms as factors affecting its operations in meeting the service level agreements. Initiatives to resolve these issues to maintain optimal quality of experience for customers at all times include resolving external Interference, deploying LTE in the lower spectrum, planning of new sites in the areas of poor coverage. Cell Range and access parameter optimisation has been checked and modified to improve accessibility and mobility.

#### 6.1.2. MTN

MTN has indicated that it will remain committed to the improvement of the network quality even in areas where performance was good, thereby improving the end user mobile voice service experience.

- Modimolle – One critical location has been identified where a new site will be built in the 2023 financial year. Five sites had availability issues, mainly due to loadshedding and have subsequently been restored, however one site had been vandalised. Antenna optimisation methods will be implemented on one of the sites to improve network coverage in the area.
- Mokopane – Poor coverage was due to mountainous terrain and operational site availability issues resulted in 81 blocked call attempts which consequently resulted to low CSSR in the area. Three locations have been identified where new coverage sites will be built from the 2023 financial year to improve network coverage. There were operational site availability issues on six sites when the drive test was conducted by the Authority and most of these issues have since been rectified.

- Lephalale – Blocked calls were experienced when the Authority conducted the drive test, and these contributed to poor CSSR network performance. These blocked call attempts are mainly due to coverage issues in the area. After analysis, MTN has identified 3 new locations where coverage sites will be built from 2023 to improve coverage in the area.
- The operator had met all the Authority’s KPIs in Ga-Seleka and Shongoane and did not provide any remedial actions.

### 6.1.3. Cell C

Cell C in its response indicated that it notes the findings of the Authority and will continue to engage with its national roaming service provider to improve coverage in areas identified with poor coverage. Cell C will further investigate the challenges of mobile roaming on a prohibited network operator.

### 6.1.4. Telkom

Telkom’s response to the report indicated that it views the Authority test results as very significant and use them as additional input to further improve the quality of the mobile network. Furthermore, Telkom indicated that they will be engaging with its roaming partners to resolve issues and improve customer experience.

The operator indicated that repairs are underway to address vandalized sites in the tested area and that the drive test was performed during Eskom Load Shedding, which affected site availability due to power failures.

Telkom has sixteen (16) planned sites, with five (5) sites in the build and lease agreement phases. Telkom continue depending mostly on its roaming partners for coverage within the villages and the joining roads.

The operator also indicated that it continues to use 1800 MHz as a coverage layer, in absence of permanently assigned 700/800 MHz spectrum, considering the limited period of provisional spectrum. Permanent assignment of sub 1 GHz spectrum to Telkom will assist to deliver increased performance and better customers experience.

## 6.2. Appendix 2: Detailed Test results per Phase

Table 4. CSSR and Call Setup Time Phase 1 and Phase 2

		Ga-Seleka		Lephalale		Modimolle		Mokopane		Shongoane		Grand Total
		Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2	
Call Attempt	Cell C	624	540	511	519	606	603	542	568	654	682	5849
	MTN	624	540	511	520	609	604	544	571	654	681	5858
	Telkom	624	539	511	521	608	604	542	572	653	681	5855
	Vodacom	624	540	511	521	605	605	545	572	654	682	5859
Call Failed	Cell C	10	12	37	39	49	41	86	14	1	0	289
	MTN	3	11	27	26	45	27	74	7	1	2	223
	Telkom	62	32	74	91	24	32	28	35	25	25	428
	Vodacom	14	25	49	54	21	19	14	35	5	9	245
Call Setup Success Ratio [%]	Cell C	98.40%	97.78%	92.76%	92.49%	91.91%	93.20%	84.13%	97.54%	99.85%	100.00%	95.06%
	MTN	99.52%	97.96%	94.72%	95.00%	92.61%	95.53%	86.40%	98.77%	99.85%	99.71%	96.19%
	Telkom	90.06%	94.06%	85.52%	82.53%	96.05%	94.70%	94.83%	93.88%	96.17%	96.33%	92.69%
	Vodacom	97.76%	95.37%	90.41%	89.64%	96.53%	96.86%	97.43%	93.88%	99.24%	98.68%	95.82%
Call Setup Time [s]	Cell C	3.24	3.25	3.68	3.64	3.65	3.56	3.89	3.65	3.38	3.30	3.52
	MTN	2.56	2.57	3.03	2.92	2.85	2.79	3.02	2.81	2.64	2.53	2.77
	Telkom	3.57	3.52	4.30	4.23	4.12	4.05	4.07	4.40	4.09	4.02	4.04
	Vodacom	3.21	3.22	4.15	3.09	3.21	3.35	3.13	3.46	2.94	3.01	3.28



Table 5. (DCR) and POLQA MOS Phase 1 and Phase2

		Ga-Seleka		Lephalale		Modimolle		Mokopane		Shongoane		Grand Total
		Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2	Phase 1	Phase 2	
Call Completed	Cell C	159	139	116	123	142	143	118	143	172	179	1434
	MTN	160	135	126	128	142	150	124	143	173	179	1460
	Telkom	151	127	115	113	143	145	131	130	167	168	1390
	Vodacom	155	134	125	123	150	148	140	128	172	177	1452
Call Dropped	Cell C	1	0	3	2	6	4	3	2	0	0	21
	MTN	0	0	2	0	6	3	3	2	0	0	16
	Telkom	2	7	2	4	5	4	6	9	0	1	40
	Vodacom	1	1	2	5	1	1	2	8	1	0	22
Drop Call Ratio [%]	Cell C	0.62%	0.00%	2.52%	1.60%	4.05%	2.72%	2.48%	1.38%	0.00%	0.00%	1.44%
	MTN	0.00%	0.00%	1.56%	0.00%	4.05%	1.96%	2.36%	1.38%	0.00%	0.00%	1.08%
	Telkom	1.31%	5.22%	1.71%	3.42%	3.38%	2.68%	4.38%	6.47%	0.00%	0.59%	2.80%
	Vodacom	0.64%	0.74%	1.57%	3.91%	0.66%	0.67%	1.41%	5.88%	0.58%	0.00%	1.49%
POLQA MOS	Cell C	3.11	3.09	3.03	3.01	3.01	3.02	2.95	3.02	3.12	3.13	3.06
	MTN	3.62	3.61	3.53	3.49	3.49	3.55	3.45	3.55	3.64	3.65	3.56
	Telkom	2.96	3.02	3.38	3.42	3.41	3.34	3.27	3.24	3.38	3.42	3.28
	Vodacom	3.34	3.31	3.36	3.36	3.58	3.55	3.42	3.33	3.41	3.46	3.42

### 6.3. Appendix 3 Technology Maps

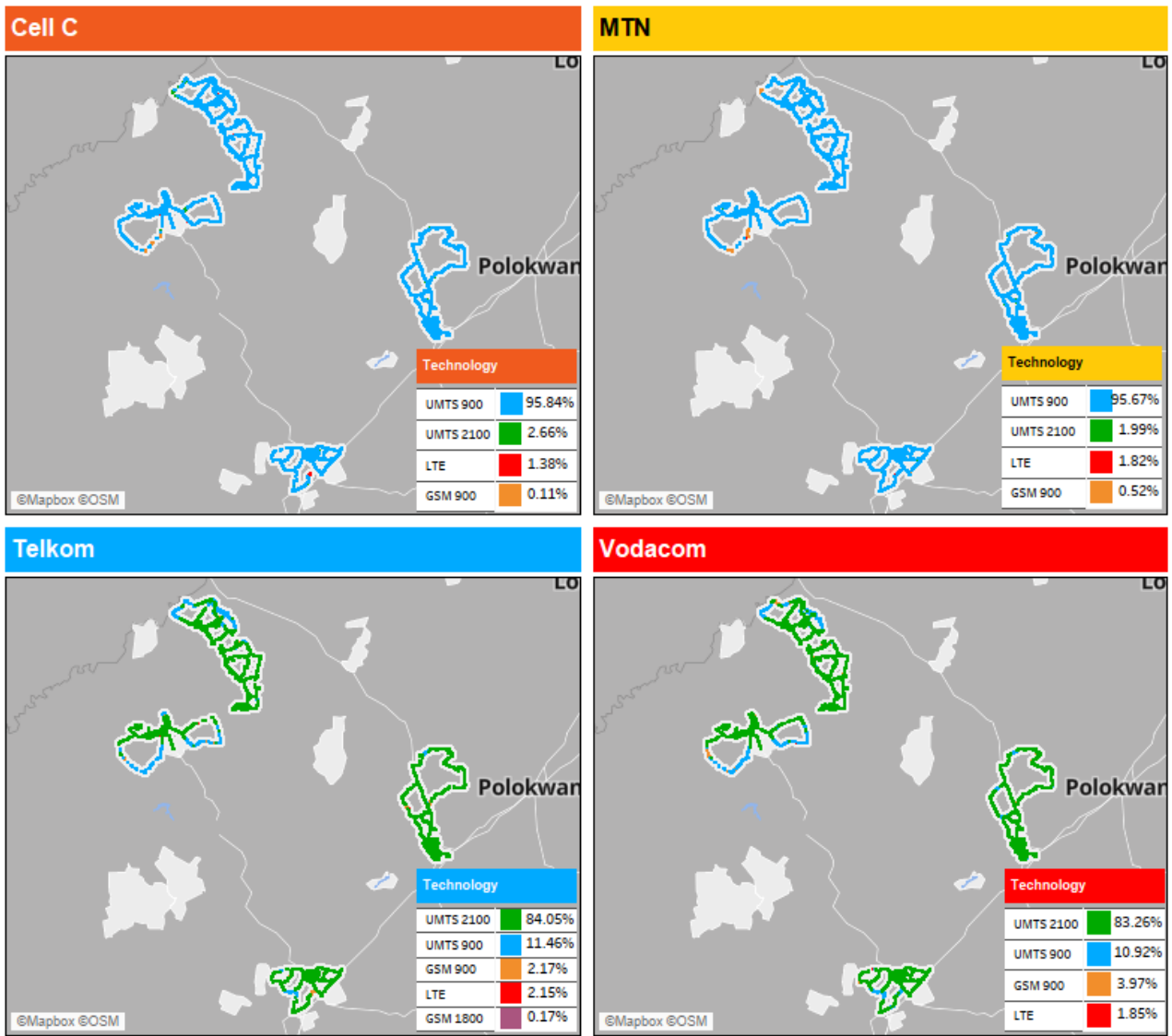


Figure 15. Radio Technology Maps

### 6.4. Appendix 4 UMTS Coverage Maps

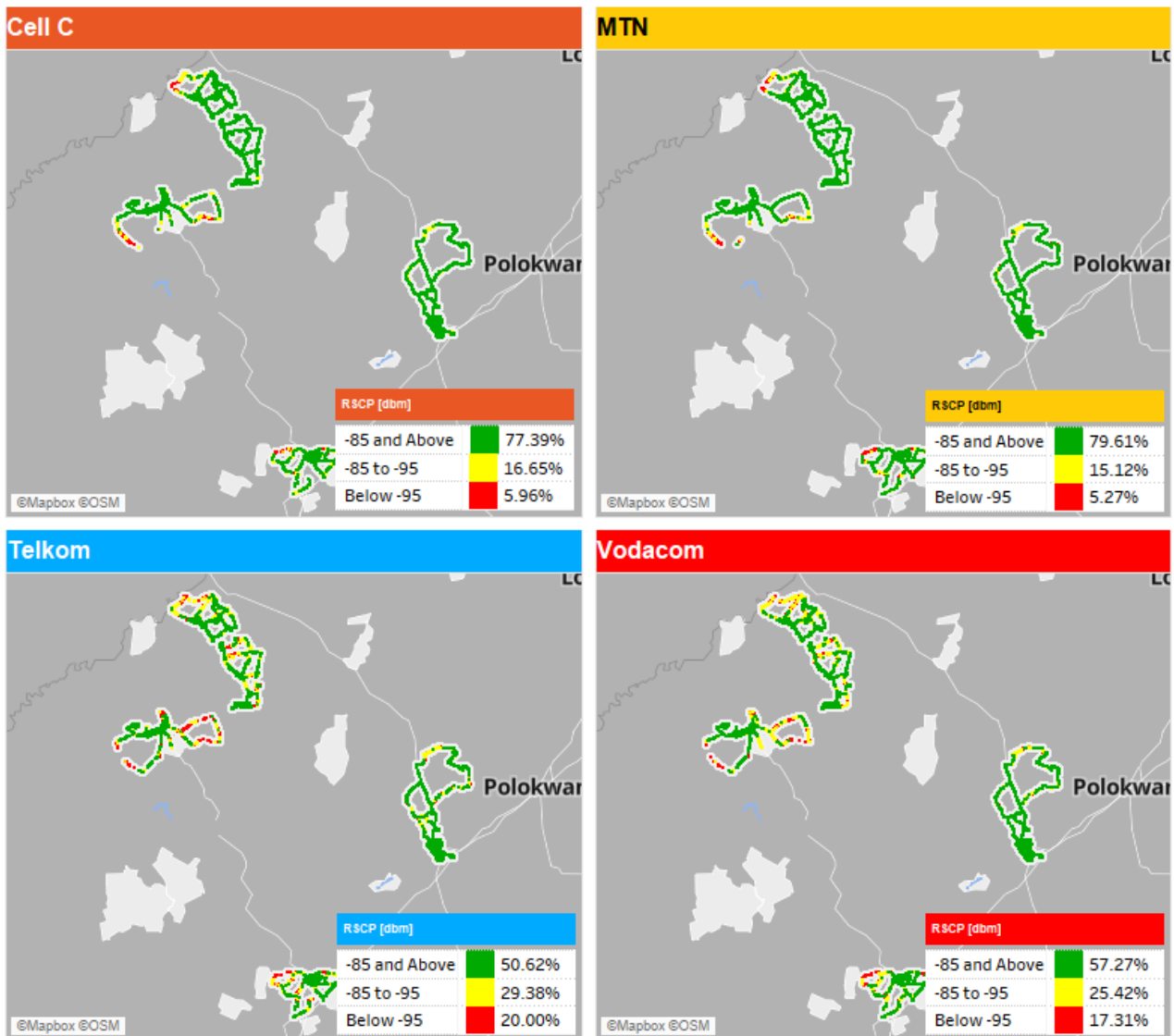


Figure 16. UMTS Coverage Maps

## 6.5. Appendix 5 UMTS Quality Map

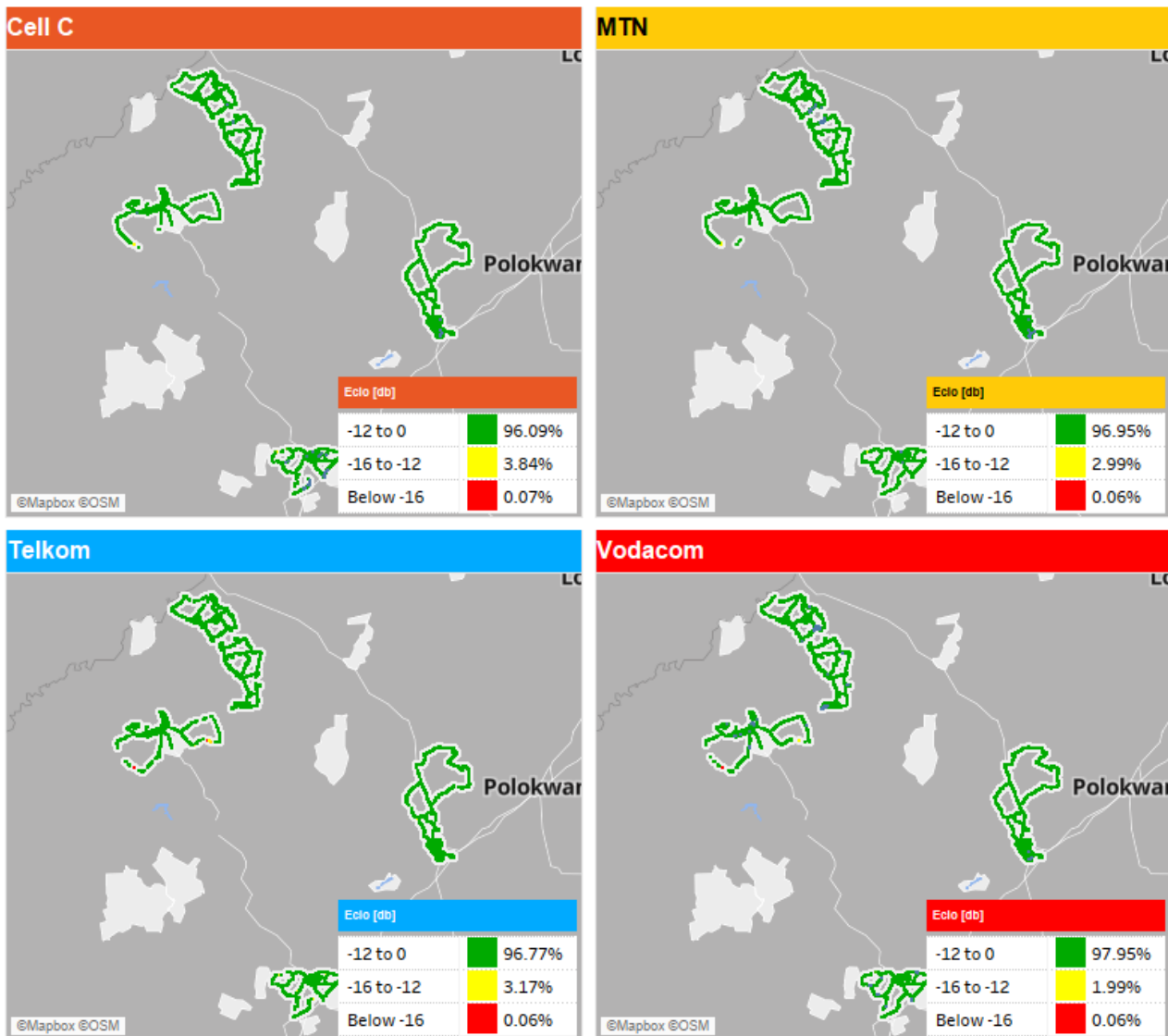


Figure 17. UMTS Quality Maps