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2020/2021 Quarter 2: Voice Quality of Service Report – Free State Province

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List of Acronyms

| | |
|-------|--|
| CD | Call Duration |
| CS | Circuit Switch |
| CSFB | Circuit Switched FallBack |
| CSSR | Call Setup Success Ratio |
| DCR | Drop Call Ratio |
| GSM | Global System for Mobile Communications |
| GERAN | GSM EDGE Radio Access Network |
| IVR | Interactive Voice Response |
| LTE | Long Term Evolution |
| WCDMA | Wideband Code Division Multiple Access |
| MOC | Mobile Originating Call |
| KPI | Key Performance Indicator |
| UMTS | Universal Mobile Telecommunications System |
| UTRAN | UMTS Terrestrial Radio Access Network |

EXECUTIVE SUMMARY

The Authority conducted 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 voice services offered by the mobile operators in the Free State Province. The measurements were carried out in the period 24 August to 15 September 2020, covering a total distance of over 2000 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 were 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. The sampled areas include Senekal, Kroonstad, Parys, Sasolburg and Deneysville.

A vehicle equipped with Keysight Nemo Autonomous measurement tool including eight mobile phones were used to collect data in mobility conditions. The three Key Performance Indicators (KPIs) used to evaluate QoS are Retainability, Accessibility and Call Setup Time.

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%. Call Setup Time must be less than 20 seconds.

All operators met the overall CSSR target of more than 98%, thus meeting the Accessibility target. MTN, Vodacom and Cell C are the only operators that met the overall DCR target of less than 3% and thus meeting the Authority's Retainability target. All operators met the target for Call Setup Time of less than 20 seconds.

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 quality of service through its Quality of Service (QoS) monitoring activities. The Authority conducted QoS monitoring of the voice telephony service being offered by Cell C, MTN, Vodacom and Telkom within the Free State Province of South Africa.

The Free State is in the geographical center of South Africa, bordered by the Northern Cape, Eastern Cape, North West, Mpumalanga, KwaZulu-Natal and Gauteng provinces, as well as Lesotho. The Free State is a rural province of farmlands, mountains, goldfields and widely dispersed towns. The third largest province in South Africa, with the second smallest population and the second lowest population density. It covers an area of 129 825 km² and has a population of 2 834 714 (5.1% of the national population). Its capital is Bloemfontein, which is South Africa's judicial capital. Other important towns include Welkom, Kroonstad, Sasolburg and Bethlehem².

The QoS monitoring was conducted in the areas within Thabo Mofutsanyana and Fezile Dabi District Municipality as shown in Figure 1. The selected areas include Senekal, Kroonstad, Parys, Sasolburg and Deneysville.

¹ ICASA Strategic Plan 2016/17-2021

²<https://www.localgovernment.co.za/provinces/view/2/free-state>

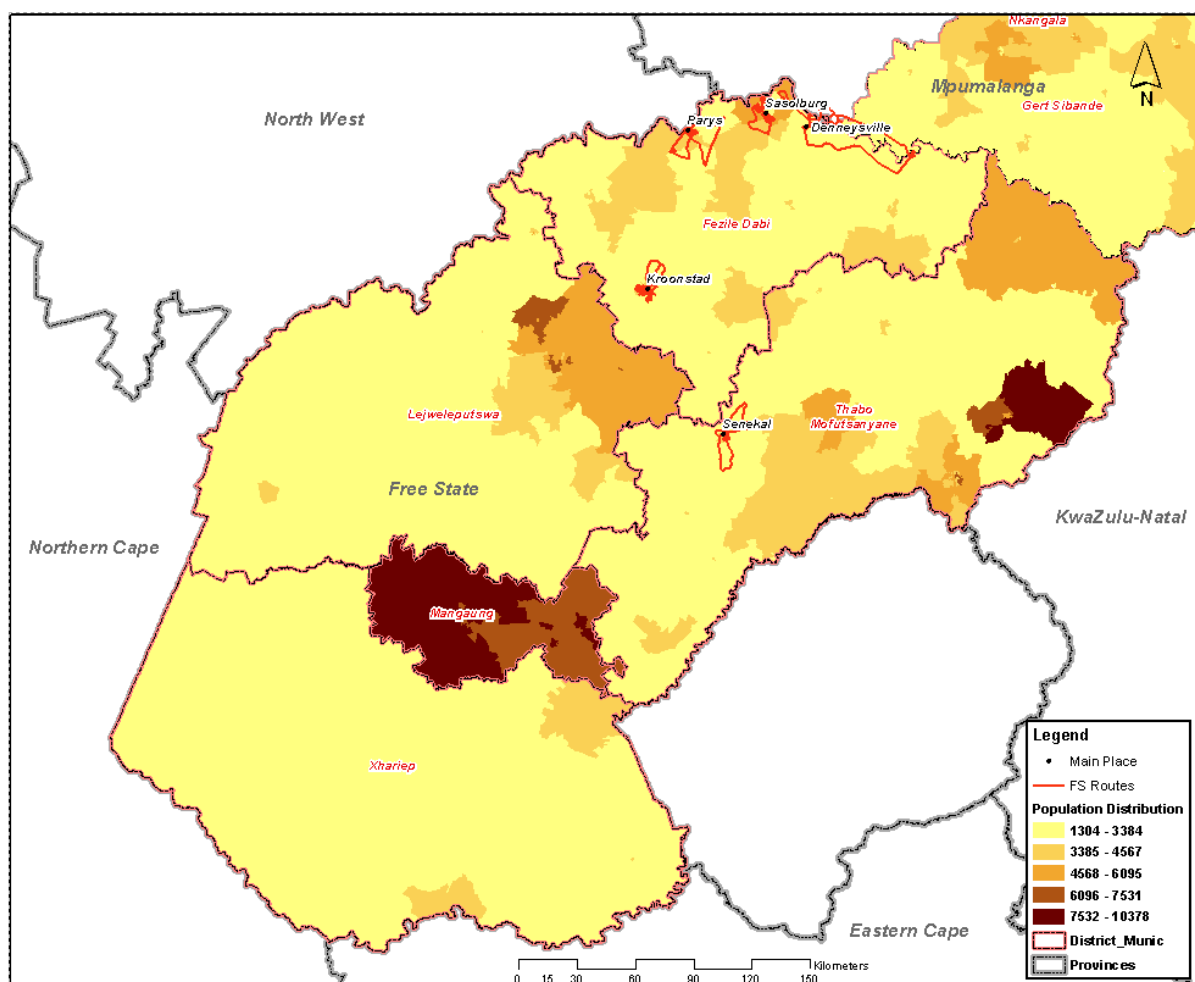


Figure 1: Free State Province Route Map

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. ICASA has selected Call Accessibility, Call Setup Time and Call Retainability parameters to evaluate QoS. These parameters are described briefly below:

- a) Call Accessibility is defined as a percentage and is a measure of the number of times a user is able to successfully establish a call as a percentage 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 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 dialed 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).

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 on the selected routes and a particular time of the day.

Voice test set-up consisted of two categories which are short call (accessibility) and long call (retainability). The Call Window was set up as follows:

- (i) Call duration + 30 seconds (for the setup and release phases) + 30 seconds (for the minimum pause interval).
- (ii) The default call duration is 120 seconds for Long Call and thus results in 180 seconds call window. The call duration for Short Call is 10 seconds resulting in 70 seconds call window.

The devices were set to measure the best available technology and barred from making VoLTE calls, thus in the areas where operators had LTE they performed Circuit Switched Fall Back (CSFB) calls. CSFB allows terminal/mobile phones connected on LTE to use GERAN or UTRAN to connect to the CS domain mainly for voice calls.

2.1 Equipment test setup and configuration

2.1.1 System/Equipment used

The drive test was carried out using a test kit comprised of four (4) Keysight Nemo Autonomous probes. Each probe has three Samsung Galaxy S8 (SM-G950F) mobile devices. The mobile devices were configured to automatically select a mobile network and radio access technology.

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:

Table 1: Selected routes and dates

| District | Route Name | Test Date |
|--------------------|-------------|------------|
| Thabo Mofutsanyana | Senekal | 24/08/2020 |
| | | 31/08/2020 |
| Fezile Dabi | Kroonstad | 25/08/2020 |
| | | 01/09/2020 |
| | Parys | 26/08/2020 |
| | | 02/09/2020 |
| | Sasolburg | 27/08/2020 |
| | | 03/09/2020 |
| | Deneysville | 07/09/2020 |
| | | 16/09/2020 |

2.3 Equipment test setup and configuration

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

Table 2: Test plan and configurations

| Configuration | Explanation |
|---------------|--|
| Antennas | Device Antennas were used as per SANS 1725-2 ³ |
| Technologies | GSM, UMTS and LTE CSFB |
| Call Samples | A minimum of 120 test samples per network operator were collected except in the areas where services were limited on |

³ SABS Standard, SANS 1725-2:2019 End user related Quality of Service parameter definitions and measurements, Part 2: Mobile data services

| | |
|---------------------------|---|
| | <p>most part of the drive test route. Drive tests 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 tests were 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 behavior⁴.</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 (CD) 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). Thus, the default call duration for Long Call resulted in 180 seconds and 70 seconds for a Short Call⁵.</p> |
| Equipment | <p>The equipment used for testing was the Keysight Nemo Autonomous probe with 3 x Samsung Galaxy S8 (SM-G950F) phones in each probe.</p> |
| KPI ⁶ | <p>The measurements focused on the following network parameters:</p> <ul style="list-style-type: none"> (i) Drop Call Ratio (DCR) (ii) Call Setup Success Ratio (CSSR) (iii) Call Setup time (CST) |
| Log files | <p>The log files for each test case were stored in different locations with different names. The log files were recorded</p> |

⁴ SABS Standard, SANS 1725-1:2016 End user related Quality of Service parameter definitions and measurements, Part 2: GSM voice services

⁵ Ibid

⁶ End User and Subscriber Service Charter Regulations of 2016

| | |
|----------------------|--|
| | per network operator. Nemo Analyzer was used to analyse the log files. |
| 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 Ford Everest 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 60 km/h in town and built-up areas and an average of 100 km/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. The 95% confidence level was used in calculating the statistical accuracy of the results.

2.5 Measurement parameters and targets

2.5.1 Targets

According to the End User and Subscriber Service Charter Regulations of 2016, the following targets have been set as the measurement parameters for the following services:

1. Call Setup Success Ratio – Average Call Setup Success Ratio must be greater than 98%;
2. Call Setup Time – Average Call Setup Time must take less than 20 seconds;
3. Drop Call Ratio – Average Drop Call Ratio must be less than 3%.⁷

⁷ https://www.icasa.org.za/uploads/files/39898_1-4_Icasa.pdf

2.5.1.1 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 call established successfully and X is the total number of call attempts.

2.5.1.2 Drop Call Ratio [%]

Drop 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 represents number of dropped calls and S is the number of successful calls established

2.5.1.3 Call Setup Time [s]

Call Setup Time refers to the time interval from the moment 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 dialed party.

3 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: Senekal, Kroonstad, Parys, Sasolburg and Deneysville.

3.1 Accessibility and Retainability Measurements

Table 3: Summary of Results

| Route Name | Operator | CSSR (%) | DCR (%) | CST (ms) |
|--|------------|----------|---------|----------|
| Senekal | Cell C | 98.95 | 0.43 | 7.11 |
| | MTN-SA | 99.48 | 1.28 | 3.91 |
| | Telkom | 98.80 | 2.95 | 5.01 |
| | VodaCom-SA | 99.34 | 0.0 | 3.99 |
| Kroonstad | Cell C | 99.37 | 0.78 | 5.81 |
| | MTN-SA | 99.67 | 0.81 | 3.58 |
| | Telkom | 99.53 | 1.17 | 5.23 |
| | VodaCom-SA | 100.00 | 0.79 | 3.50 |
| Parys | Cell C | 98.96 | 0.74 | 5.97 |
| | MTN-SA | 99.85 | 0.37 | 3.49 |
| | Telkom | 99.11 | 3.01 | 5.53 |
| | VodaCom-SA | 97.65 | 2.17 | 3.30 |
| Sasolburg | Cell C | 97.83 | 2.52 | 5.68 |
| | MTN-SA | 98.80 | 1.67 | 4.02 |
| | Telkom | 99.71 | 3.78 | 5.34 |
| | VodaCom-SA | 98.12 | 4.17 | 3.98 |
| Deneysville | Cell C | 95.45 | 5.65 | 3.37 |
| | MTN-SA | 99.18 | 4.74 | 2.19 |
| | Telkom | 98.04 | 4.33 | 2.68 |
| | VodaCom-SA | 99.02 | 3.92 | 2.09 |
| Overall results for the above 5 areas | Cell C | 98.16 | 1.95 | 6.50 |
| | MTN-SA | 99.41 | 1.77 | 3.31 |
| | Telkom | 98.98 | 3.04 | 5.33 |
| | VodaCom-SA | 98.71 | 2.52 | 3.73 |

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

NB: Vodacom IVR system had technical challenges during Phase 1 drive test at Senekal, Kroonstad, Parys and Sasolburg. Hence, only Phase 2 results are reported for the retainability measurements at these areas.

3.1.1 Call Setup Success Ratio (CSSR)

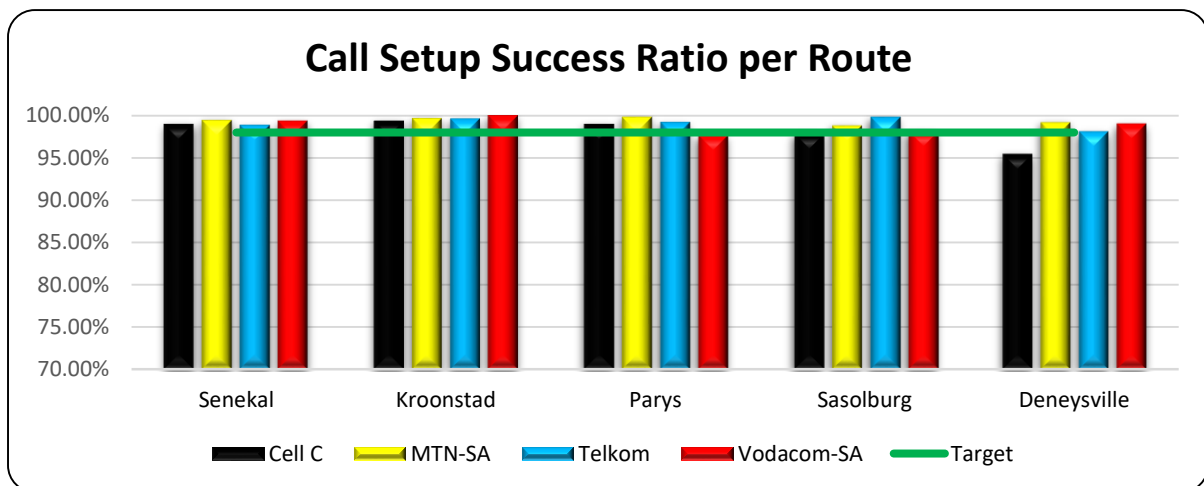


Figure 2: Call Setup Success Ratio (CSSR) per Route

Figure 2 shows that MTN and Telkom met the 98% CSSR target in all tested areas. Vodacom failed to meet the target in Parys, while Cell C failed in Sasolburg and Deneysville.

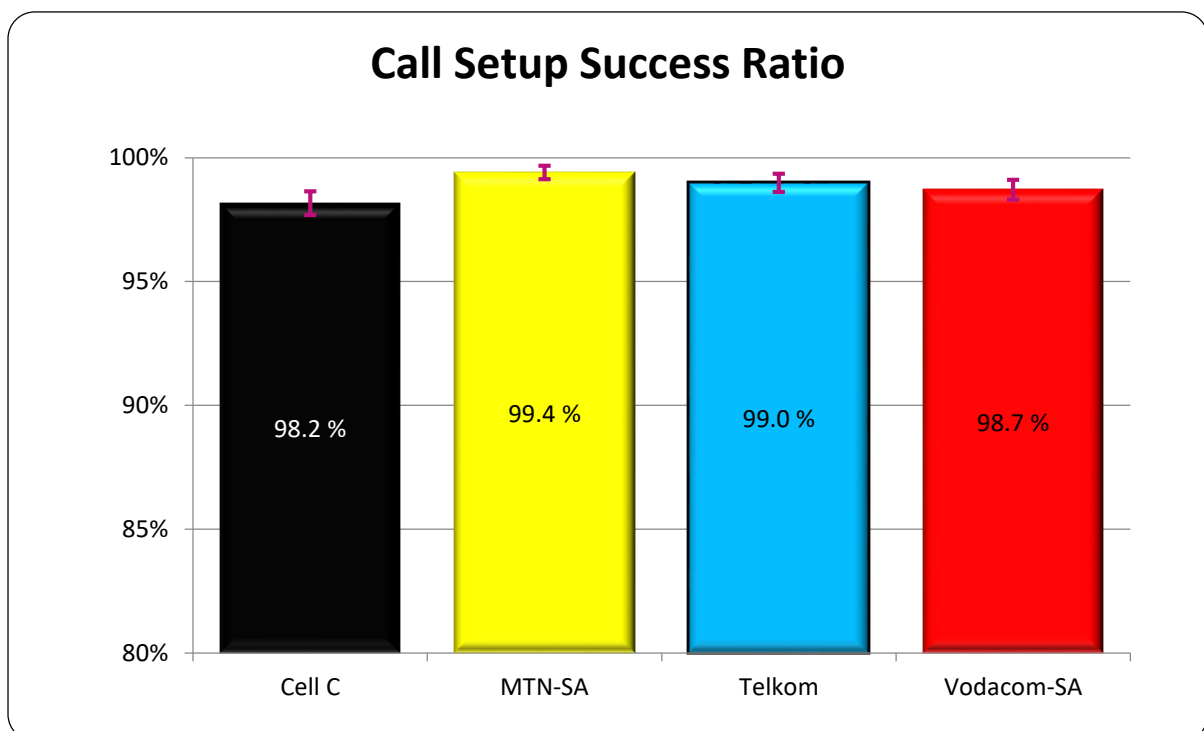


Figure 3: Overall Call Setup Success Ratio with Statistical Significance

Figure 3 shows that MTN's overall CSSR is the highest, followed by Telkom, Vodacom and Cell C in the descending order respectively. All the operators

performed well above 98%. There is a no statistically significant difference recorded between Cell C, Vodacom and Telkom, as well as between MTN, Telkom and Vodacom; and between Telkom and Vodacom. There is statistically significant difference between Cell C and MTN, as well as between MTN and Vodacom.

3.1.2 Drop Call Ratio (DCR)

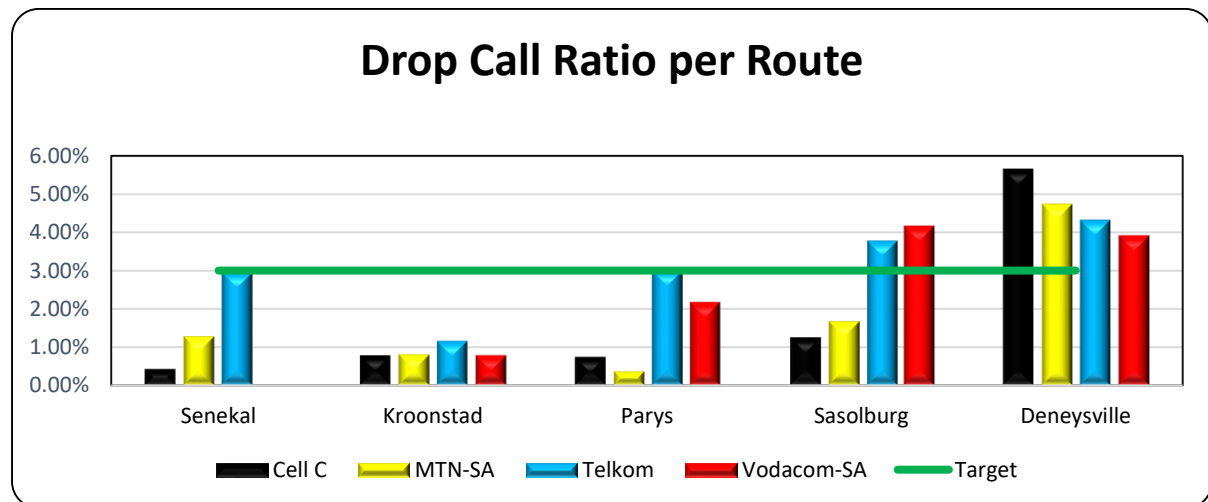


Figure 4: Drop Call Ratio (DCR) per Route

Figure 4 shows that MTN and Cell C met the 3% DCR target in Senekal, Kroonstad, Parys and Sasolburg and failed to meet the target in Deneysville. Telkom met the DCR target in Senekal and Kroonstad but failed to meet the target in Parys, Sasolburg and Deneysville. Vodacom met the DCR target in Senekal, Kroonstad and Parys but failed to meet the target in Sasolburg and Deneysville.

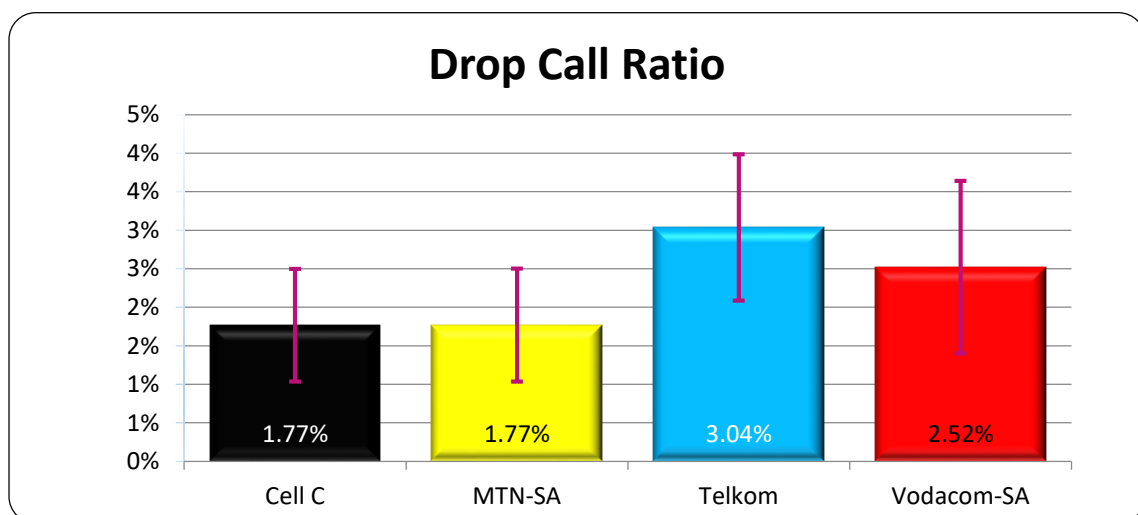


Figure 5: Total Drop Call Ratio with Statistical Significance

Figure 5 shows that Cell C and MTN overall DCR are the lowest followed by Vodacom and Telkom in an ascending order respectively. Cell C, MTN and Vodacom met the 3% overall DCR target, but Telkom failed to meet the target. There is a no statistically significant difference recorded between all operators.

3.1.3 Call Setup Time (CST)

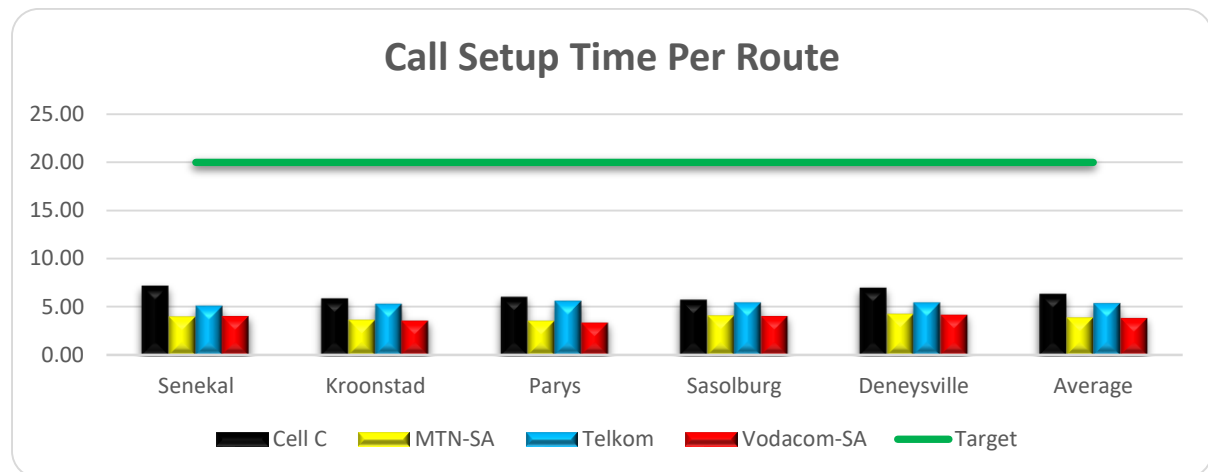


Figure 6: Call Setup Time [s] per area

Figure 6 shows that all operators met the call setup time of 20 seconds target in all tested areas.

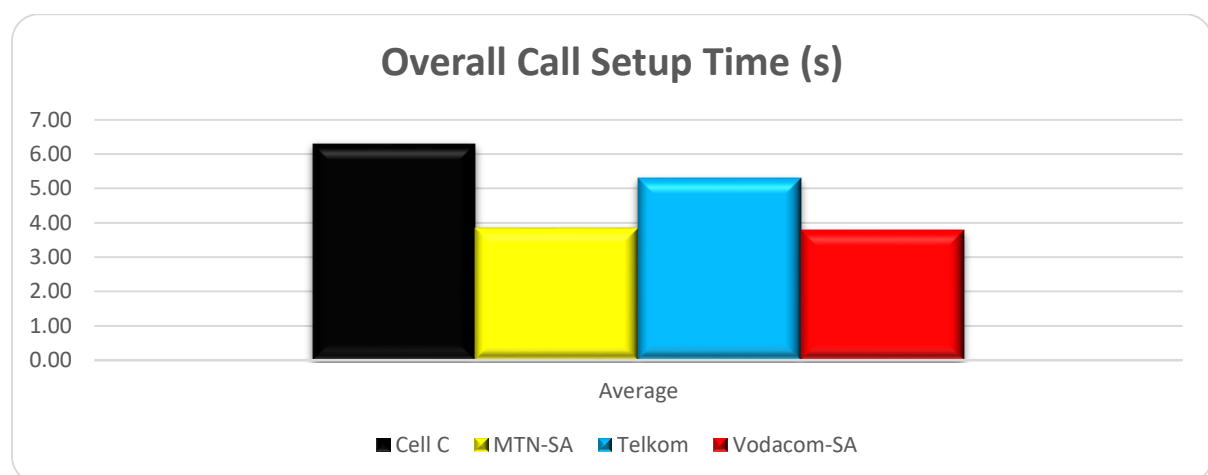


Figure 7: Call Setup Time [s] overall results

Figure 7 shows that the overall results for Call Setup Time. Vodacom has the lowest overall Call Setup Time, followed by MTN, Telkom and Cell C in ascending order.

3.2 Analysis of the serving technology

The serving technology distribution were based on the devices 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 8 below shows the statistical distribution of the serving technology during the drive test. MTN, Telkom and Vodacom serving technology distribution was mainly on LTE, while Cell C was mainly on WCDMA.

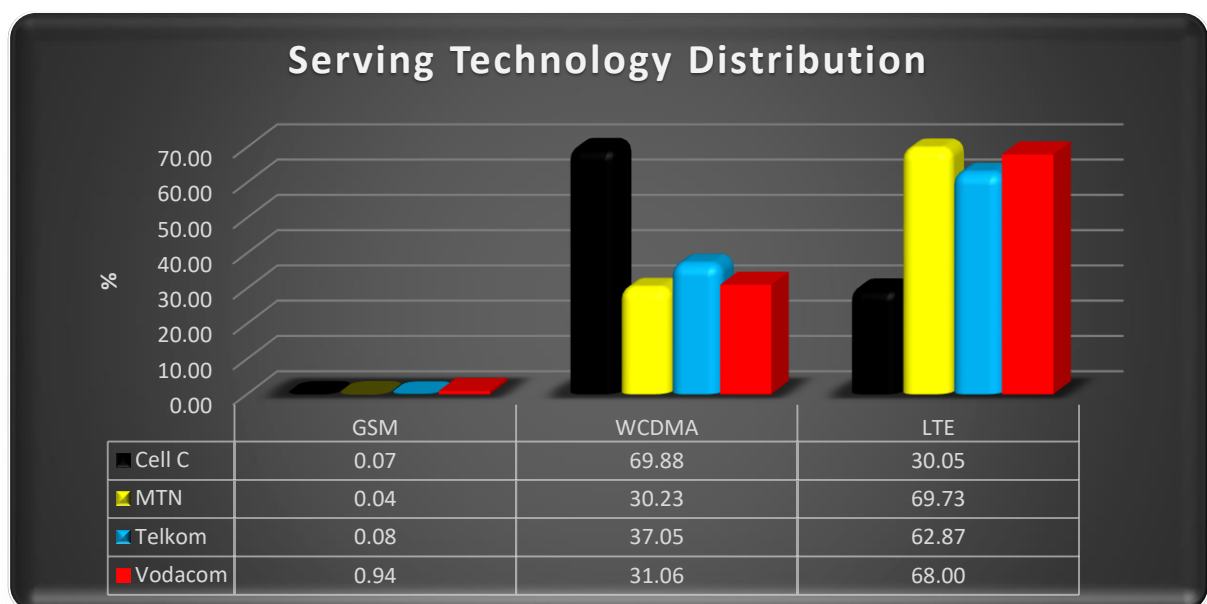


Figure 8: Technology Distribution

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

3.1 Comparison of current results to previous results

Senekal was previously monitored in the financial year 2014/2015. Kroonstad and Sasolburg were previously monitored in the financial year 2017/18. The aim of conducting the recent QoS measurements in the area was to assess the level of improvement that the operators promised in the previous financial years. The results show that there is consistent good performance from all operators in Senekal and Sasolburg, as well as an improvement on Cell C in terms of Retainability. In terms of Accessibility; MTN, Telkom and Vodacom show a

significant improvement, while Cell C maintained good performance in the areas. Telkom and Vodacom did not improve from previous Sasolburg results. Telkom was not yet included in the measurements during the financial year 2014/15.

It must be noted that the target for Accessibility was 95% in 2014/2015, this is before the revision of *End-User and Subscriber Service Charter Regulations of 2016* which became effective on 1 April 2016. Table 4 below summarises the previous and current results.

Table 4: Comparison with previous results

| Route | Financial Year | Accessibility (%) | | | | Retainability (%) | | | |
|-----------|----------------|-------------------|-------|--------|---------|-------------------|------|--------|---------|
| | | Cell C | MTN | Telkom | Vodacom | Cell C | MTN | Telkom | Vodacom |
| Senekal | 2014/15 | 99.14 | 98.84 | - | 99.69 | 3.45 | 0.00 | - | 0.75 |
| | 2020/21 | 98.95 | 99.48 | 98.80 | 99.34 | 0.43 | 1.28 | 2.95 | 0.00 |
| Kroonstad | 2017/18 | 99.45 | 98.64 | 96.30 | 93.22 | 2.19 | 0.38 | 0.71 | 0.36 |
| | 2020/21 | 99.37 | 99.67 | 99.53 | 100.00 | 0.78 | 0.81 | 1.17 | 0.79 |
| Sasolburg | 2017/18 | 95.60 | 97.87 | 97.15 | 98.08 | 5.88 | 3.19 | 2.62 | 2.27 |
| | 2020/21 | 97.83 | 98.80 | 99.71 | 98.12 | 1.26 | 1.67 | 3.78 | 4.17 |

4 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 is relatively good in the Free State province.

Senekal, Kroonstad and Sasolburg were monitored in the previous monitoring exercises.

After benchmarking the operators, the results show that in terms of overall Call Setup Success Ratio; all operators (Telkom, MTN, Cell C and Vodacom) met the target of 98%, thus meeting the Accessibility target. In terms of overall Drop Call Ratio, Telkom was the only mobile operator that failed to meet the DCR target of less than 3%. In terms of overall Call Setup Time all four mobile operators met the target.

There is consistent good performance and improvements in the Province. The good performance could be attributed due to the following factors:

- High investment in infrastructure, and
- Roaming arrangements between operators.

There is a continuous improvement on network performance in Kroonstad and Sasolburg since the last measurements that were done in 2014/15 and 2017/18; with the exception of Vodacom and Telkom retainability results in Sasolburg.

5 APPENDICES

5.1 Appendix A: Drive Test Results KPI's

Table 5: 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 (%) |
| Senekal | Cell C | 119 | 1 | 0.84 | 116 | 0 | 0.00 | 235 | 1 | 0.43 |
| | MTN-SA | 118 | 3 | 2.54 | 116 | 0 | 0.00 | 234 | 3 | 1.28 |
| | Telkom | 119 | 1 | 0.84 | 118 | 6 | 5.08 | 237 | 7 | 2.95 |
| | VodaCom-SA | - | - | - | 114 | 0 | 0.00 | 114 | 0 | 0.00 |
| Kroonstad | Cell C | 128 | 2 | 1.56 | 127 | 0 | 0.00 | 255 | 2 | 0.78 |
| | MTN-SA | 119 | 2 | 1.68 | 127 | 0 | 0.00 | 246 | 2 | 0.81 |
| | Telkom | 131 | 3 | 2.29 | 126 | 0 | 0.00 | 257 | 3 | 1.17 |
| | VodaCom-SA | - | - | - | 127 | 1 | 0.79 | 127 | 1 | 0.79 |
| Parys | Cell C | 127 | 0 | 0.00 | 142 | 2 | 1.41 | 269 | 2 | 0.74 |
| | MTN-SA | 130 | 1 | 0.77 | 142 | 0 | 0.00 | 272 | 1 | 0.37 |
| | Telkom | 128 | 2 | 1.56 | 138 | 6 | 4.35 | 266 | 8 | 3.01 |
| | VodaCom-SA | - | - | - | 138 | 3 | 2.17 | 138 | 3 | 2.17 |
| Sasolburg | Cell C | 120 | 0 | 0.00 | 119 | 3 | 2.52 | 239 | 3 | 1.26 |
| | MTN-SA | 122 | 2 | 1.64 | 117 | 2 | 1.71 | 239 | 4 | 1.67 |
| | Telkom | 119 | 2 | 1.68 | 119 | 7 | 5.88 | 238 | 9 | 3.78 |
| | VodaCom-SA | - | - | - | 120 | 5 | 4.17 | 120 | 5 | 4.17 |
| Deneysville | Cell C | 117 | 6 | 5.13 | 131 | 8 | 6.11 | 248 | 14 | 5.65 |
| | MTN-SA | 120 | 6 | 5.00 | 133 | 6 | 4.51 | 253 | 12 | 4.74 |
| | Telkom | 121 | 6 | 4.96 | 133 | 5 | 3.76 | 254 | 11 | 4.33 |
| | VodaCom-SA | 122 | 6 | 4.92 | 133 | 4 | 3.01 | 255 | 10 | 3.92 |
| Total Provincial Samples | Cell C | | | | | | | 1246 | 22 | 1.77 |
| | MTN-SA | | | | | | | 1244 | 22 | 1.77 |
| | Telkom | | | | | | | 1252 | 38 | 3.04 |
| | VodaCom-SA | | | | | | | 754 | 19 | 2.52 |

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

| Route Name | Operator | PHASE 1 | | | | | PHASE 2 | | | | Call Setup Time | TOTAL | | | | |
|---------------------------------------|------------|--------------|------------|--------------|----------|-----------------|--------------|------------|--------------|----------|-----------------|--------------|------------|--------------|----------|-------------------------|
| | | Call Attempt | Call Setup | Call Attempt | CSSR (%) | Call Setup Time | Call Attempt | Call Setup | Call Attempt | CSSR (%) | | Call Attempt | Call Setup | Call Attempt | CSSR (%) | Average Call Setup Time |
| Senekal | Cell C | 288 | 285 | 3 | 98.96 | 7.27 | 286 | 283 | 3 | 98.95 | 6.94 | 574 | 568 | 6 | 98.95 | 7.11 |
| | MTN-SA | 288 | 287 | 1 | 99.65 | 3.95 | 287 | 285 | 2 | 99.30 | 3.87 | 575 | 572 | 3 | 99.48 | 3.91 |
| | Telkom | 295 | 295 | 0 | 100.00 | 5.12 | 287 | 280 | 7 | 97.56 | 4.89 | 582 | 575 | 7 | 98.80 | 5.01 |
| | VodaCom-SA | 332 | 328 | 4 | 98.80 | 3.97 | 276 | 276 | 0 | 100.00 | 4.02 | 608 | 604 | 4 | 99.34 | 3.99 |
| Kroonstad | Cell C | 318 | 315 | 3 | 99.06 | 5.38 | 312 | 311 | 1 | 99.68 | 6.24 | 630 | 626 | 4 | 99.37 | 5.81 |
| | MTN-SA | 295 | 293 | 2 | 99.32 | 3.71 | 312 | 312 | 0 | 100.00 | 3.45 | 607 | 605 | 2 | 99.67 | 3.58 |
| | Telkom | 320 | 317 | 3 | 99.06 | 5.29 | 314 | 314 | 0 | 100.00 | 5.17 | 634 | 631 | 3 | 99.53 | 5.23 |
| | VodaCom-SA | 123 | 123 | 0 | 100.00 | 3.54 | 314 | 314 | 0 | 100.00 | 3.47 | 437 | 437 | 0 | 100.00 | 3.50 |
| Parys | Cell C | 323 | 318 | 5 | 98.45 | 5.35 | 348 | 346 | 2 | 99.43 | 6.58 | 671 | 664 | 7 | 98.96 | 5.97 |
| | MTN-SA | 321 | 320 | 1 | 99.69 | 3.41 | 354 | 354 | 0 | 100.00 | 3.56 | 675 | 674 | 1 | 99.85 | 3.49 |
| | Telkom | 320 | 319 | 1 | 99.69 | 5.59 | 351 | 346 | 5 | 98.58 | 5.47 | 671 | 665 | 6 | 99.11 | 5.53 |
| | VodaCom-SA | 369 | 363 | 6 | 98.37 | 3.32 | 353 | 342 | 11 | 96.88 | 3.28 | 722 | 705 | 17 | 97.65 | 3.30 |
| Sasolburg | Cell C | 299 | 294 | 5 | 98.33 | 5.54 | 300 | 292 | 8 | 97.33 | 5.83 | 599 | 586 | 13 | 97.83 | 5.68 |
| | MTN-SA | 300 | 300 | 0 | 100.00 | 3.52 | 285 | 278 | 7 | 97.54 | 4.53 | 585 | 578 | 7 | 98.80 | 4.02 |
| | Telkom | 294 | 293 | 1 | 99.66 | 5.59 | 55 | 55 | 0 | 100.00 | 5.10 | 349 | 348 | 1 | 99.71 | 5.34 |
| | VodaCom-SA | 345 | 342 | 3 | 99.13 | 3.29 | 294 | 285 | 9 | 96.94 | 4.66 | 639 | 627 | 12 | 98.12 | 3.98 |
| Deneysville | Cell C | 281 | 270 | 11 | 96.09 | 6.74 | 290 | 275 | 15 | 94.83 | 7.05 | 571 | 545 | 26 | 95.45 | 6.90 |
| | MTN-SA | 289 | 288 | 1 | 99.65 | 4.39 | 323 | 319 | 4 | 98.76 | 3.95 | 612 | 607 | 5 | 99.18 | 4.17 |
| | Telkom | 292 | 285 | 7 | 97.60 | 5.36 | 320 | 315 | 5 | 98.44 | 5.35 | 612 | 600 | 12 | 98.04 | 5.35 |
| | VodaCom-SA | 291 | 288 | 3 | 98.97 | 4.17 | 320 | 317 | 3 | 99.06 | 4.04 | 611 | 605 | 6 | 99.02 | 4.11 |
| Overall results for the above 5 areas | Cell C | | | | | | | | | | | 3045 | 2989 | 56 | 98.16 | 6.50 |
| | MTN-SA | | | | | | | | | | | 3054 | 3036 | 18 | 99.41 | 3.31 |
| | Telkom | | | | | | | | | | | 2848 | 2819 | 29 | 98.98 | 5.33 |
| | VodaCom-SA | | | | | | | | | | | 3017 | 2978 | 39 | 98.71 | 3.73 |

5.2 Appendix B: Coverage Maps

Serving Technology Details

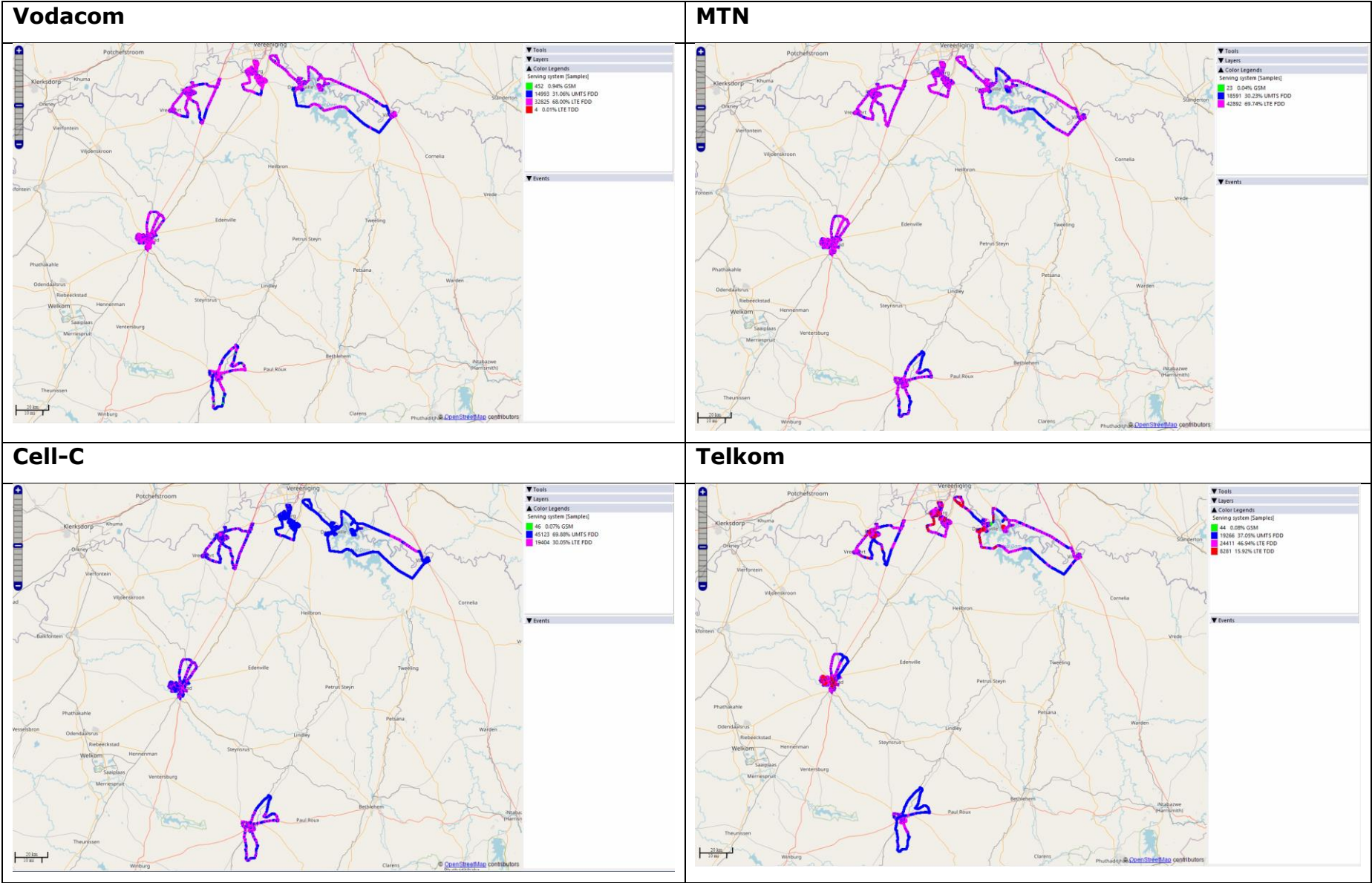


Figure 7: Free State Province Serving Technology Plot